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Agricultural Research Service Program Plan

Implementation Plan—

6 Year

1992 - 1998

Foreword

I am pleased to present the Agricultural Research Service (ARS) program implementation plan for the period 1992-1998. This document outlines those research programs to receive emphasis by the agency in the coming 6 years. Just as important, the plan describes the policies and strategies ARS will follow to acquire, deploy, and manage resources needed to carry out its research programs. The plan also addresses the need for human workforce forecasting and modernization of facilities to support future programs.

Today, agriculture faces a multitude of research challenges. Issues involving the environment and natural resource conservation, agricultural sustainability, food safety, human nutrition, waste management, animal well-being, and genetic resources have steadily moved to the forefront. The competitive position of U.S. agricultural products in the global marketplace must be bolstered, while demands for alternative energy sources are being raised more widely. The cutting edge of science, particularly bioscience, is advancing rapidly. ARS must keep up with that cutting edge if agriculture is to benefit from the innovations it will generate.

ARS identification of these many problems and research opportunities has emerged through joint planning and priority setting processes using inputs from numerous sources, including the Secretary of Agriculture, other USDA policy officials, Congress, research users, scientists, cooperators, and the general public. ARS program leaders have worked hard to assimilate these many inputs and reach a consensus on future program directions and areas of research emphasis within the ARS mission and available resources. The collective judgments are presented in this plan, but ARS will remain flexible so we can adapt to changing conditions and priorities, as necessary.

I want to emphasize the special working and planning relationships ARS shares with its fellow USDA agencies and with other performers and users of agricultural research in the state systems and the private sector, as we jointly plan, conduct, and coordinate our research. We have a particularly close relationship with the USDA Cooperative State Research Service (CSRS), the State agricultural experiment stations (SAES), and the 1890 Land Grant Institutions. In implementing future research, it is clear that we must all increasingly address issues of broad public and consumer concern in addition to continuing to be responsive to the needs of farmers and ranchers, the agribusiness sector, and other traditional users of agricultural research.

ARS has made considerable progress in accomplishing the goals and objectives established in the 1984 and 1986 program plans. I am convinced that ARS, with a dedicated workforce committed to scientific excellence, accountability, and public service, will meet the new challenges presented in this plan.

R.D. Plowman
Administrator

Agricultural Research Service Program Plan
6-Year Implementation Plan—1992-1998

Executive Summary

I. Introduction

The Agricultural Research Service (ARS) Implementation Plan is a principal means of informing ARS personnel, funders, clientele, and cooperators about the agency's research program objectives. This plan updates two previous plans covering 1984-1992.[1,2] It establishes areas of research emphasis for 1992-1998 and outlines ARS policies and strategies to achieve them. This updated plan reflects changing national needs and priorities including those presented in the 1990 Farm Bill.[3]

As the in-house research arm of the U.S. Department of Agriculture, ARS has a mission to:

> Develop new knowledge and technology needed to solve technical agricultural problems of broad scope and high national priority in order to ensure adequate production of high-quality food and agricultural products to meet the nutritional needs of the American consumer, to sustain a viable food and agricultural economy, and to maintain a quality environment and natural resource base.

ARS has primary responsibility to:

- Provide initiative and leadership in agricultural research.
- Conduct research on broad regional and national agricultural and related problems.
- Conduct research in support of Federal action and regulatory agencies.
- Provide technical expertise to meet national food, food safety, and environmental emergencies.
- Serve as an agricultural science resource to the executive and legislative branches.

ARS programs are centrally planned and coordinated. The agency manages the scientific and operational activities of 129 locations, which comprise a network of geographically dispersed national and overseas laboratories. Supported by appropriated funds, ARS provides:

- Ability to perform long-term, high-risk research.
- Ability to respond to stable and changing technical goals.

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[1] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1984-1990. U.S. Department of Agriculture, Agricultural Research Service. 1983. (Out of print.)
[2] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1986-1992. U.S. Department of Agriculture, Agricultural Research Service. 1985. (Out of print.)
[3] Public Law 101-624; November 28, 1990. Food, Agriculture, Conservation, Trade Act of 1990.

- An organizational structure ensuring research program accountability and coordination.

- Ability to focus research on gaps in knowledge that are barriers to problem solution.

- Capability to form, disband, or coordinate interdisciplinary or multilocation research teams from a large, diverse scientific workforce of over 2,600 research scientists, including postdoctoral research associates.

Challenges of the 1990's

Issues critically important to ARS' research mission include:

Environment. Public concern has increased about effects of air and water pollution on the environment, depletion of nonrenewable resources, waste management, and potential effects of global warming. At issue is the role of the agricultural sector as a contributor to or solver of environmental problems contrasted with the need to sustain supplies of agricultural products for domestic consumption and export.

Food Safety, Human Nutrition, and Health. Public concern over chemical and biological contamination of food during production and processing continues, with more recent concern over the safety of biotechnology products. Another concern is the relationship between diet and health, which is compounded by the complexities of nutrition.

National Economy. Since the U.S. share of the agricultural export market has slipped from peak levels in 1980-1981, lowering costs, adding value, and improving quality of U.S. agricultural products are potential ways to reduce the trade deficit, boost U.S. market share, and otherwise enhance U.S. agricultural competitiveness.

Scientific and Technical Approaches. Scientific research is changing, driven by major trends:

- Increased use of biotechnology, interdisciplinary teams, and computer automation.

- Increased dependence of the private sector on public research capabilities, particularly for fundamental and pre-market research.

- More effective transfer of new knowledge and technologies to users or further developers. Public/private sector research collaboration is a growing component of this positive trend.

ARS Response to These Challenges—The Implementation Plan 1992-1998

The research challenges of the 1990's have critical policy, program, and operational implications for ARS. Section II broadly describes ARS progress in implementing strategies and program priorities laid out in the previous versions of the plan and profiles current (1991) ARS base resources—funding, personnel, and facilities. Program priorities are identified as areas of research emphasis in section III. Section IV describes how ARS will implement its program within the limits of its fiscal, human, and physical resources.

II. ARS 1991 Status—Planning Base

Research Progress

For research planning and resource allocation purposes the ARS program is divided into six areas, termed objectives:[1]

Objective 1—Soil, water, and air

Objective 2—Plant productivity

Objective 3—Animal productivity

Objective 4—Commodity conversion and delivery

Objective 5—Human nutrition

Objective 6—Integration of systems

The objectives are further divided into scientific approaches, then into approach elements.

Fulfillment of Previous Implementation Strategies

Selected examples in appendix D show ARS progress in implementing the previously planned strategies, which were:

- Adhere to mission-oriented research.
- Address technical problems determined to be most critical to the U.S. agricultural sector.
- Allocate resources to solve specific high-priority national problems.
- Increase use of interdisciplinary teams in problem solving.
- Institute and expand integrative systems research.
- Augment research to increase the efficiency of production and marketing.
- Develop communication networks and data-management systems to support research and facilitate technology transfer.

[1] Agricultural Research Service Program Plan. U.S. Department of Agriculture, Agricultural Research Service, Miscellaneous Publication 1429. 1983. (Out of print.)

Current Status—Funding, Personnel, Facilities

Funding

- Although appropriations to ARS increased by 47 percent between 1982 and 1991, the real purchasing power increased only 7 percent because of an inflation of almost 37 percent over the same period.

- Total dollar levels required for conducting research projects have increased. The 1991 figure is 67 percent higher, $250,000 per scientist year. Thus, the ARS budget currently supports fewer career scientists and research projects than in previous years.

- There has been little change in the balance of funding between ARS research objectives, although significant changes in research direction have been made within objectives. ARS continues to respond to user expectations and be accountable for appropriations.

Personnel

- ARS is at its currently authorized personnel ceiling of 8,200 full time equivalents, including about 2,600 permanent and temporary scientists. The ceiling has changed little since 1986, and no significant future changes are expected.

- Through normal attrition, ARS expects to turn over about 36 percent—780 positions—of its permanent scientist workforce in the next 6 years. ARS must redeploy these positions wisely.

- ARS disciplinary structure is already changing to meet the new demands of emerging programs and science. One means has been an increase in postdoctoral appointments in 1991 to 14 percent of the total ARS scientist workforce, from 7 percent in 1986 and 1 percent in 1982.

Facilities

A forward-planning program of facilities renovation and modernization (R&M) to meet the challenge of an aging ARS infrastructure has been underway for several years. Assessment of the current situation is as follows:

- ARS' real property inventory includes nearly 3,000 separate buildings and facilities that comprise about 12 million square feet of floor space. The current replacement value of these and other capital improvements is about $1.7 billion.

- A significant part of this real property needs renovation or replacement to adapt to safety, health, and other regulatory code requirements and to meet technical demands of future research programs.

- From 1987 to 1990, ARS allocated about $106 million in base program and special appropriated funds to R&M (about $26.5 million per year).

- Current plans for 1992 to 1998 project a need to double annual expenditures for facility modernization.

- ARS facility improvement priorities will be driven by program needs.

III. ARS Program Strategy—1992-1998

Areas of research emphasis for ARS during the 1992 to 1998 period respond to high-priority problems identified by scientists, internal ARS program evaluation, users, new legislation, appropriations, action and regulatory agency concerns, and executive branch initiatives.

Base Program

Objective 1. Soil, Water, and Air

- Improved production systems for reducing the degradation of water quality by agricultural chemicals and controlling erosion under low-crop-residue conditions.
- Strategies for off-site control of chemical buildup in ground water.
- Technologies for improving chemical application efficiencies; using agricultural, municipal, and industrial wastes to improve soil productivity; and delineating land areas vulnerable to soil degradation.
- Methods for assessing the effect of potential global climate change on water and energy fluxes, water resources, and the health and sustainability of agroecosystems; for quantifying agriculture's contribution to the fluxes of greenhouse gases; and for facilitating conservation tillage.
- Evaluation and optimization of no-till and other conservation tillage and residue management systems to increase soil organic matter, infiltration, and soil biological activity and to reduce runoff, erosion, evaporation, and drought damage.

Objective 2. Plant Productivity

- Enhancement of plant germplasm by genome manipulation at the molecular level and of plant genetic resources to overcome productivity barriers in major crops.
- Technologies for controlling fundamental biological processes relating to productivity, market quality, and production costs; long-and short-term acquisition and preservation of plant germplasm; and detection at the molecular level of pathogens in propagative material.
- Methods for nondestructive testing of seed viability and composition and for environmentally safe pest control with acceptable health risk.
- Management systems for sound ecosystem maintenance and water use on important range, pasture, and crop lands (including horticultural crops); weed and plant disease control; and areawide control of high-priority pests.
- Development of a relational database for the National Plant Germplasm System.

- Computer simulation models for growth and development of economically important crops and weeds.

Objective 3. Animal Productivity

- Means to reduce mortality and other losses from disease and parasites, improve—at the molecular level—genetic resistance to diseases and parasites, use biologically based control of parasites, control zoonotic bacteria and parasites in the live animal, increase the genetic capacity of animals for greater production, and evaluate behavioral, physiological, and productivity indicators of animal well-being.

- Elucidation of physiological processes involved in feed intake and metabolism and mechanisms by which chemical and physical composition of feed limits nutrient availability.

- Technology for nondestructive repeated measurements of body composition.

- Means to use animal wastes and means to reduce waste contamination of surface and ground water.

Objective 4. Commodity Conversion and Delivery

- Means to prevent or eliminate foodborne microorganisms in animal products, prevent mycotoxins in food and feed products, eliminate insect and disease trade barriers limiting agricultural exports, meet commodity quality market requirements (physical, sanitary, performance), and extend shelf life with sensory quality retention.

- Methods for rapid, objective analysis of marketing safety and quality characteristics.

- Technologies for conversion of agricultural commodities to value-added industrial products, alternative fuels, and new fiber, leather, feed, and food products; process treatments to enhance food safety, minimize residues or additives, and retain quality; and alternative environmentally benign processes and products.

Objective 5. Human Nutrition and Well-Being

- Methods to determine composition of commonly consumed foods for several nutrients and phytogenic components and to change food production and processing systems to improve food nutritional quality.

- Elucidation of role of dietary components in weight maintenance and risk of chronic diseases, adequate and safe ranges of nutrient and calorie intake, and molecular and cellular basis of human nutrition.

Objective 6. Integration of Systems

Areas of emphasis for objective 6 are included under objectives 1 through 5 where appropriate. Integrative systems research aimed at more general goals will be a critical component of planning and setting priorities for related implementation strategies.

High-Priority ARS Special Programs

ARS Plant Genome Program/Animal Genome Program

- Gene construction for broad genetic similarities and differences for useful gene maps of major species.
- Gene construction for important economic traits of major species for which some data already exist.
- Development of new mapping and sequencing technologies; electronic data management for data access and dissemination; and robotics and automation for new, automatic DNA processing procedures.
- Identification of genes or groups of genes responsible for desired productivity traits and resistance to diseases and parasites.
- Application of new knowledge and techniques to modify plants and animals so as to improve production efficiency, nutritional quality and safety of food, and U.S. competitiveness in export markets.

ARS Global Climate Change Research Program

- Climate and hydrologic systems that will affect policy responses to greenhouse and atmospheric warming, water supplies, food security, biochemical dynamics, ozone depletion, biological productivity and diversity, and forestation.
- Ecological systems and dynamics and causes and effects related to how ecosystems cause global change and how they are affected by global change.

ARS Utilization Research Program

- Substantial-value-added products such as chemical pesticide substitutes, edible films, biodegradable industrial and food products, industrial enzymes, and food additives.
- High-value-added products such as biomedical and veterinary products, essences, attars, and flavors.
- Moderate-value-added products such as bulk fermentation chemicals and replacements for significant imports such as latex, vegetable gums, and specialty vegetable oils.

High-Priority ARS Crosscutting Programs

Food Safety

- Reduction or elimination of introduced toxicants, with emphasis on chemical contaminants, mycotoxins, and toxin-producing and pathogenic microorganisms.

- Reduction or elimination of toxins that occur naturally in plants and cause stock losses in animal production, transfer to animal products, or occur in plants that are directly consumed by humans and are potentially significant to human health.

Improved Human Nutrition and Health

- Definition of human nutritional requirements for optimal function and safe limits of energy and nutrient intakes through the life cycle, with emphasis on infants, pregnant and lactating women, and the elderly.

- Research on molecular and cellular basis of human nutrition to yield data applicable to reduction of risks associated with obesity and chronic disease.

- Research to determine the bioavailability of nutrients important to health in agricultural products as eaten.

- Development of methods to assess marginal nutritional status under field conditions.

- Development of biotechnology, management, and processing strategies to change food production systems that will enhance the nutritional value of animal and plant foods.

Water Quality Protection

- Research to assess agricultural effects on water quality, with emphasis on fundamental processes affecting fate and transport of agricultural chemical contaminants and evaluation of current agricultural practices.

- Development of new agricultural practices and systems to remediate or preclude water quality problems in cropping areas and to reduce effects on other ecosystems.

Environmentally Compatible Pest Control

- Fundamental research to unravel complexities of microbial and other biological associations that affect efficacy of biological control agents.

- Development of new systems for pest management designed to keep pest populations below the economic damage threshold, including host genetic resistance.

- Development of crop cultural practices complementary to cultivars with genetic resistance to pests.

- Research leading to development of alternative disease management strategies.

Section IV. Implementation Strategy 1992-1998

1. ARS will continue to carry out that research necessary to solve specific, identified problems. ARS will use a total quality management (TQM) and integrated systems-based approach to research planning.

2. ARS will continue to depend on sustained appropriated funds for its base programs.

3. ARS will aggressively seek annual budget increases to address new priority research needs and to strengthen important base programs.

4. ARS will seek outside funding support to supplement or accelerate in-house programs consistent with base-funded project objectives and the accountability requirements of the Department, Congress, and research users.

5. ARS will not depend on new or outside funds alone to address priority research, but will manage and effectively deploy its existing base resources to address its most important research objectives and approaches.

6. ARS will maintain research projects at well-funded levels adjusted for inflation (current projections are $250,000 per year for each career scientist). Resource redeployment decisions will use established decision criteria.

7. ARS will develop means to implement long-range workforce planning to meet the challenges of projected scientific needs, increase cultural diversity and achieve other Equal Employment Opportunity objectives, and properly reward its scientists for contributions to achieving ARS' mission, goals, and objectives.

8. ARS will systematically upgrade and modernize its facilities and seek budget allocations to augment its limited base resources for this purpose.

9. ARS will develop multiyear operational planning by line (area) management and integrate its planning process into long-range strategic planning.

10. ARS will improve its support functions, especially the technology transfer operations, to achieve planned agency goals and objectives.

Preface

This plan is an update of two previous Agricultural Research Service (ARS) plans (6-Year Implementation Plan 1984-1990,[1] and 1986-1992 [2]). Such plans are one of the principal means by which ARS informs its personnel, funders, clientele, and cooperators about agency research program objectives for the planning period. They also provide the policies and strategies by which ARS proposes to achieve those objectives. The 6-Year Implementation Plan designates those areas of research ARS will emphasize in the next 6 years within the broad programmatic framework established in 1983 in the Agricultural Research Service Program Plan.[3] This new plan reflects ARS' response to changing national needs and priorities, including those addressed in the 1990 Farm Bill.[4]

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[1] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1984-1990. U.S. Department of Agriculture, Agricultural Research Service. 1983. (Out of print.)
[2] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1986-1992. U.S. Department of Agriculture, Agricultural Research Service. 1985. (Out of print.)
[3] Agricultural Research Service Program Plan. U.S. Department of Agriculture, Agricultural Research Service, Miscellaneous Publication 1429. 1983. (Out of print.)
[4] Public Law 101-624; November 28, 1990. Food, Agriculture, Conservation, and Trade Act of 1990.

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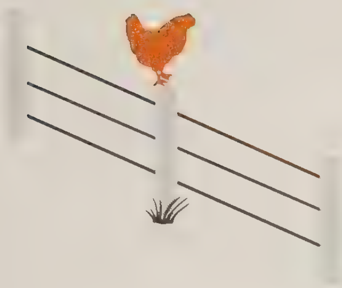

Section I — Introduction

ARS Mission

As the in-house research arm of the U.S. Department of Agriculture, the Agricultural Research Service has a mission to:

Develop new knowledge and technology needed to solve technical agricultural problems of broad scope and high national priority in order to ensure adequate production of high-quality food and agricultural products to meet the nutritional needs of the American consumer, to sustain a viable food and agricultural economy, and to maintain a quality environment and natural resource base.

ARS Responsibilities

ARS has primary responsibility to:

Provide initiative and leadership in agricultural research.

Conduct research on broad regional and national agricultural and related problems.

Conduct research in support of Federal action and regulatory agencies.

Provide technical expertise to meet national food, food safety, and environmental emergencies.

Serve as an agricultural science resource to the executive and legislative branches.

Mission Implementation

ARS programs are centrally planned and coordinated to ensure accountability and responsiveness to national needs and priorities. ARS manages the scientific and operational activities of 129 locations, which comprise a network of geographically dispersed national and overseas research centers and laboratories. The ARS organizational and management structure (appendix A), supported by appropriated funds, provides:

- Ability to perform long-term and high-risk research sustained by base funding.
- Ability to maintain a research program responsive to both stable and changing technical goals.
- National program leadership to geographically deployed laboratories to ensure accountability and coordination of research programs.
- Ability to focus research—fundamental and applied—on gaps in knowledge identified by ARS as technical barriers to problem solution.

- Critical capability to form, disband, or coordinate interdisciplinary or multilocation research teams.

- A large and diverse scientific workforce (over 2,500 research scientists of many disciplines), which allows ARS to rapidly build scientific teams to meet challenges.

Challenges of the 1990's

Since the last update of ARS' Implementation Plan in 1985 (the 1986-1992 plan [1]), broad public trends and concerns have emerged or intensified with regard to agriculture, the environment, and the economy. These issues influence decisions regarding ARS program projections and implementation strategies. Issues of critical importance to the research mission include:

Environment. Over the last decade, public concern about the environment has grown, resulting in increasing governmental involvement at national, State, and local levels. Public awareness has heightened about the effects of air and water pollution on human well-being and the ecosystem, depletion of nonrenewable resources (fossil fuels, ground water, arable soils), waste management, and potential effects of global warming should it occur. This awareness translates to conflicting concerns about the role of the agricultural sector as a contributor to or solver of environmental problems on the one hand and the need to sustain supplies of agricultural products in the face of population growth worldwide on the other.

Food Safety, Human Nutrition, and Health. Public concern over chemical and biological contamination of food during production and processing continues. Recently, the public has also become concerned over the safety of biotechnology products. Both issues have been subject to emotional swings of public opinion. Another concern has been the relationship between diet and health, which is compounded by the complexities of nutrition. In all cases, addressing these concerns requires research.

National Economy. The United States experienced severe economic pressures during the 1980's. The negative balance of trade is a significant factor in these pressures. Since the U.S. share of the agricultural export market has slipped from the peak levels of 1980-1981, lowered costs and improved quality of U.S. agricultural products are potential ways to reduce the trade deficit, boost U.S. market share, and otherwise enhance U.S. agricultural competitiveness.

Scientific and Technical Approaches. Less visible to the general public, but increasingly recognized by the scientific community, is the fact that the very nature of scientific research is changing. At least four identifiable trends are contributing to these changes.

- Increased use of the tools of biotechnology and computer automation in scientific research and problem solving.

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[1] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1986-1992. U.S. Department of Agriculture, Agricultural Research Service. 1985. (Out of print.)

- Increasing use of interdisciplinary research teams—and in some cases multilocation and/or multi-institutional teams—to solve complex problems.

- Increased dependence of the private sector on public research capabilities, particularly to carry out fundamental and other pre-market research that will lead to a better private sector ability to develop and commercialize new products.

- Increased effort by public sector research institutions to more effectively transfer new knowledge and technologies to the users or further developers of research. Public sector/private sector research collaboration is an important component of this trend.

All these trends are positive and should be enhanced to improve research efficiency and further accelerate the development of acceptable technologies to solve global food and agricultural problems to produce food for a burgeoning world population in a safe and environmentally compatible way.

ARS Response to These Challenges—The Implementation Plan 1992-1998

The research challenges of the 1990's have critical policy, program, and operational implications for ARS. Section II of this document broadly describes ARS progress in implementing strategies and program priorities laid out in the 1984 and 1986 versions of the implementation plan. Also included in section II are profiles and analyses of current (1991) ARS base resources—funding, personnel, and facilities.

Program priorities identified in this plan (section III) are contingent on base funding capabilities and resources in light of national needs and interests. The details of the ARS strategy are outlined in the sections which follow.

Section IV of the plan describes the policies ARS will use to operate and implement its established national program priorities within the limits of its fiscal, human, and physical resources.

Section II — ARS 1991 Status—Planning Base

Introduction

In the 1984 and 1986 versions of this plan, ARS established certain program objectives and seven implementation strategies. These objectives and strategies focused research and resources on specific high-priority national problems.

Between 1984 and 1990, ARS made considerable progress towards achieving its strategic goals and objectives. This section outlines the current ARS program structure, profiles recent ARS funding and current status, reports progress in carrying out past areas of research emphasis and the seven previous implementation strategies, and summarizes ARS personnel and facility status.

ARS Program Structure

The total ARS program broadly covers six discrete areas that were first defined in the 1983 ARS Program Plan.[1] Termed objectives, these six program areas are:

Objective 1—Soil, water, and air

Objective 2—Plant productivity

Objective 3—Animal productivity

Objective 4—Commodity conversion and delivery

Objective 5—Human nutrition and well-being

Objective 6—Systems integration

For purposes of research classification and resource tracking, the objectives are divided into scientific approaches, which in turn are subdivided into approach elements and problems. The current ARS program classification structure is displayed through the approach element level, in appendix B. This classification system is primarily a description of the full scope of areas of research appropriate to the ARS mission. It is not a statement of research priorities or areas of emphasis which are presented in section III.

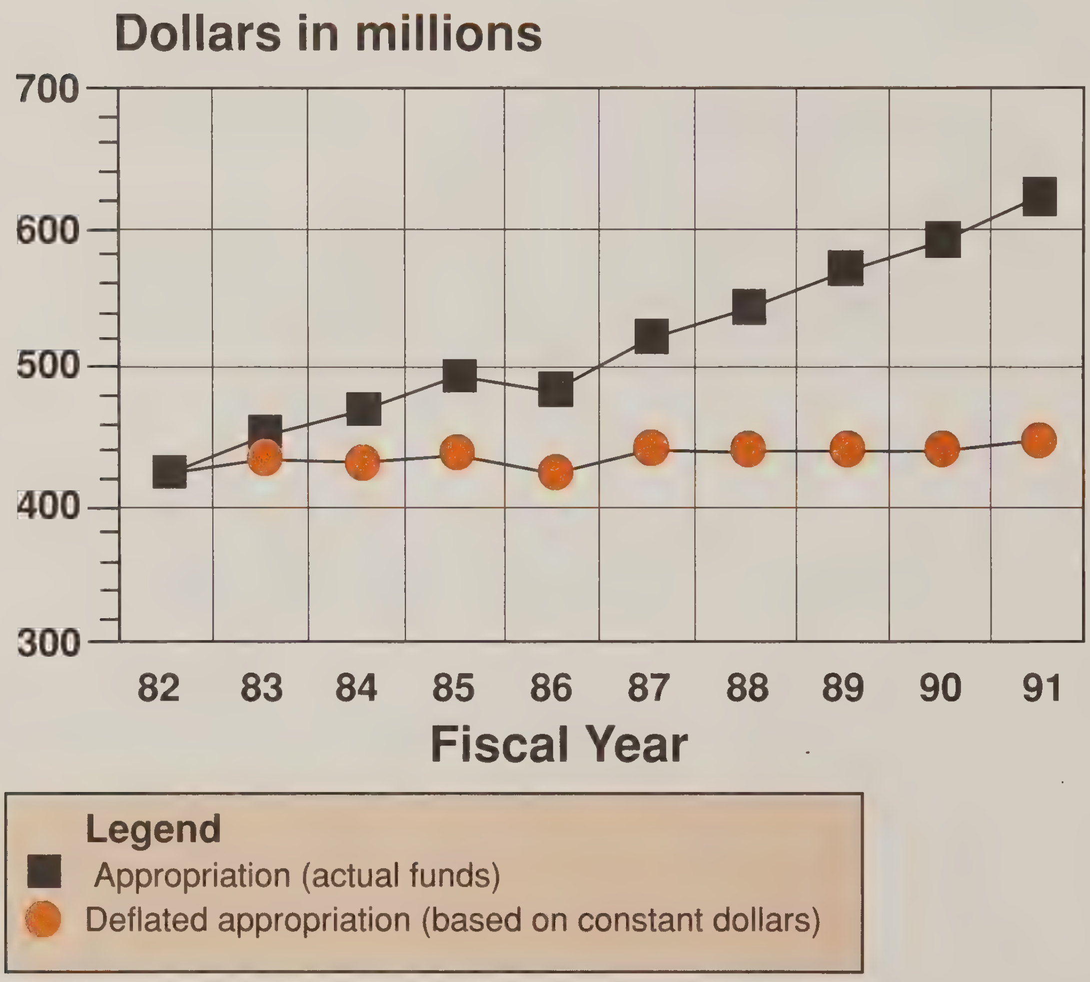
Funding Status 1991

Appropriations to ARS base programs during the 1982-1991 period increased by 47 percent from the FY 1982 level of $426 million to the FY 1991 level of $624 million. Adjusted for inflation—as measured by the Implicit Price Deflator for GNP[2,3]—which increased almost 37 percent during this period—the ARS appropriation

[1] Agricultural Research Service Program Plan. U.S. Department of Agriculture, Agricultural Research Service, Miscellaneous Publication 1429. 1983. (Out of print.)
[2] Economic Report to the President, Table C-3:—Implicit Price Deflator for GNP, February 1991.
[3] President's Budget FY '92, Table III.1: Economic Assumptions of Price Level-GNP Deflator.

actually increased by only 7 percent from the 1982 base year in terms of purchasing power of the dollar. The funding history of ARS during the 1982-1991 period is shown in figure 2.1.

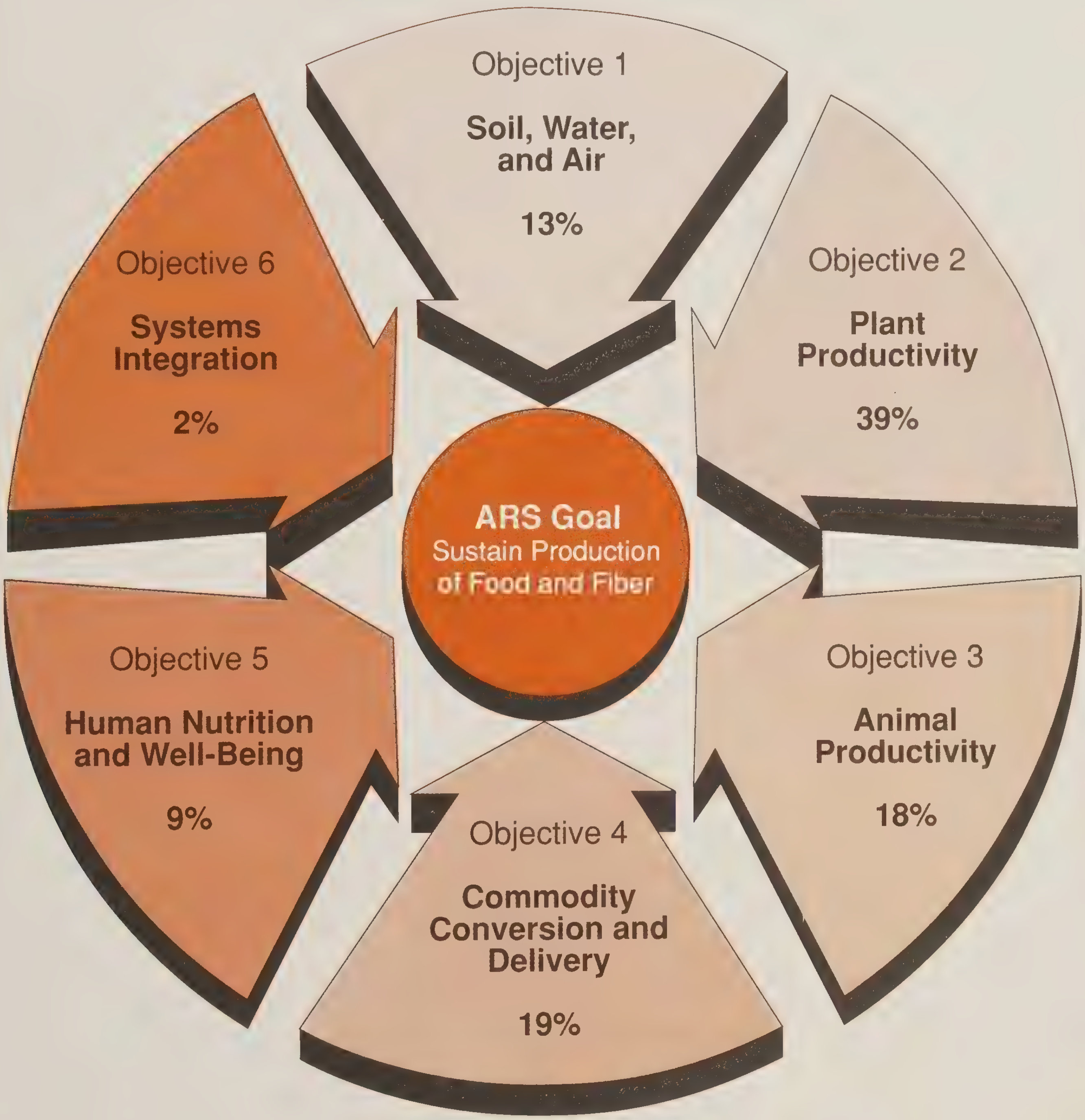
Figure 2.1. ARS Funding Trends 1982–1991



Inflation and other increased costs of conducting research such as advanced analytical equipment, computers, safety guidelines, and other regulations on laboratory practices have raised the total dollar levels required to support a single scientist and to carry out an individual research project. In 1982, the planning figure was $150,000 per scientist per year; the current planning figure is 67 percent higher at $250,000 per scientist per year. Because of this increase, the total ARS budget supports significantly fewer career scientists and research projects today than in 1982. These inflationary trends and their effects have significantly influenced development of future ARS program implementation and resource management strategies.

ARS funding allocations to each of the six objectives in 1991, expressed as percent of total ARS funding, are shown in figure 2.2. Little change has occurred in the balance of funding across objectives since 1982 because of continued ARS response to user priorities and accountability for earmarked appropriations.

Figure 2.2. Six Major Objectives of ARS



**Percentage is funding for each objective in 1991.
Total funding, $624 million.**

Research Program Status—Progress in Implementing Past Areas of Research Emphasis

Even though the balance of funds among objectives has not changed greatly since 1984, significant changes in research directions and funding allocations among scientific approaches within objectives have taken place. These changes have been in response to changing priorities, shifting research needs, new scientific data, need to exploit promising new research leads or research successes, and normal project turnover. These changes have occurred as a result of a combination of targeted budget increases and redirected ARS base resources.

Shifting of base funds to high-priority areas of emphasis is also readily apparent in the funding trends for the approach elements from 1985 to 1991 (appendix C). These data reflect the combined effect of resource shifts to areas of specific emphasis, shifts to broader national program areas, and normal project turnover.

Examples of ARS research progress since 1984 are given in appendix D.

Progress Toward Fulfilling Implementation Strategies

The seven implementation strategies in the two earlier versions of this plan provided a framework for focusing research on high-priority national problems.

These seven implementation strategies were:

- Adhere to mission-oriented research.
- Address technical problems determined to be most critical to the U.S. agricultural sector.
- Allocate resources to solve specific high-priority national problems.
- Increase use of interdisciplinary teams in problem solving.
- Institute and expand integrative systems research.
- Augment research to increase the efficiency of production and marketing.
- Develop communication networks and data-management systems to support research and facilitate technology transfer.

During the 1980's, ARS made considerable progress towards implementing these strategies. Program and administrative actions taken include new ARS policies, new ARS organizational elements, improved operating processes, new program focus, specific program augmentation, technology transfer, and new cooperative research arrangements. Most of these processes have become institutionalized within ARS and contribute to the existing foundation of ARS operations and program strategies.

Listed below are a few selected examples of major accomplishments arising from these and other ARS actions:

- Significant increases in funding for natural resource and food safety research programs.

- Development by the National Program Staff (NPS) of a centralized priority-setting process that includes recommendations from many sources, such as the Secretary, other USDA policy officials, Congress, user clientele, university cooperators, professional societies, and ARS scientists and other personnel.

- Improved systems for managing and accounting for allocated resources. Components of the new system include a computer-based research management database and information system, an annual management plan for organizational units, and a location accounting system.[1]

- Increased use of interdisciplinary teams—reflected in fewer projects, increased dollar allocations to projects, increased numbers of scientists assigned to a given project, an increased number of postdoctoral positions, an increased ratio of postdoctoral to caree scientist positions, and shifts in the balance of individual scientific disciplines within the total ARS scientific workforce.

- Augmented integrative systems research, which led, for example, to establishment of a new Systems Research Laboratory, a water erosion prediction program (WEPP), and development of the GOSSYM/COMAX cotton production expert system model (cooperative with Mississippi and South Carolina Agricultural Experiment Stations).

- New programs in production efficiency and product quality research include grading instrumentation, increase in animal and plant yield, genetic approaches to quality improvement, reduction of animal fat content, fat substitutes, improved crop protection, and removal of genetic yield barriers.

- New systems for data management and technology transfer were developed and include adding of some 150 research findings monthly to the Cooperative Extension System communications database and completion and maintenance of the Germplasm Resources Information Network (GRIN). An active technology transfer program handling a growing number of cooperative research and development agreements with private industry was established, and the number of patents filed by ARS scientists showed an upward trend after 1987. Technology transfer activities were also fostered by a technology transfer awards program, a 50-percent increase in the ARS patent staff, an eightfold increase in patent license income, and increased participation in the Federal Laboratory Consortium technology transfer conference program.

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[1] These improved systems are:
a. RMIS (Research Management Information System), computer database for multiyear science and budget guidance.
b. ARMP (Annual Resource Management Plan), a 1-year fiscal and personnel computerized operating plan system based on formal allocations to individual ARS research projects (CRIS (Current Research Information System) work units).
c. LOTS (Location Operations Tracking System), a computerized system capable of tracking actual CWU (CRIS work unit) spending against allocations.

Personnel Status—1991 Workforce Analysis[1]

The ARS workforce is currently at about its 1991 authorized personnel ceiling of 8,200 FTE's (full-time equivalents), including 2,600 scientists. The total ceiling has not changed significantly in the last 5 years, and ARS expects no significant changes in the future. Therefore, ARS must continue to deploy its available workforce strength in the most effective way possible to carry out its mission.

One mechanism already being used to obtain the use of disciplinary skills needed for new research approaches is postdoctoral hires. Temporary postdoctoral scientists now make up 14 percent of the total ARS scientist workforce, up from 7 percent in 1986 and 1 percent in 1982. This has resulted from a planned postdoctoral program and deliberate management decisions to reorient certain research programs and to infuse new skills and capabilities when attrition occurs.

One major objective for future ARS personnel policy and practice is to ensure that changing program needs and priorities will drive recruitment strategies and hiring decisions.

Current projections of the permanent ARS scientist workforce turnover indicate windows of opportunity to meet the needs of a dynamic program. These projections show that if turnover proceeds at the normal 6-percent rate of scientist attrition, an estimated 130 scientists per year will leave the agency. Thus, about 780 scientist positions will turn over in the next 6 years. The ARS scientist age profile indicates that this turnover rate may be even higher in the subsequent planning period.

Careful management of the expected vacant scientific positions during the planning period and retraining of some ARS scientists are necessary if ARS is to remain at the cutting edge of scientific knowledge and technology development.

Such personnel management opportunities must also be used to improve the mix of disciplines in high-priority projects.

There are already indications that the ARS disciplinary structure is changing to meet the new demands of emerging programs and science. Increases in the critical areas of genetics, electronics, biotechnology, nutrition, and meteorology (table 2.1) are related to high-priority programs. Continued efforts to change the disciplinary mix to meet program needs are required. The shift from general disciplines to the more highly specialized is a good indication of increases in interdisciplinary teams.

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[1] Agricultural Research Service, Workforce Analysis, January 1990. Prepared by Office of the Deputy Administrator for Administrative Management, Personnel Division.

Table 2.1. Changes Resulting From Program Shifts in Distribution of ARS Research Scientists by Discipline, FY 1986 to 1990[1]

Occupational Series	Number		Change	Percent
	Fy 86	Fy 90		
Botany	19	21	2	11
Chemistry	541	467	-74	-14
Ecology	9	12	3	33
Engineering				
Agricultural	153	129	-24	-16
Chemical	31	27	-4	-13
Civil	39	32	-7	-18
Electronic	1	4	3	300
General	7	2	-5	-71
Mechanical	6	3	-3	-50
Entomology	385	337	-48	-12
Food technology	36	35	-1	-3
General bioscience	34	49	15	44
Genetics	186	218	32	17
Geology	6	5	-1	-17
Hydrology	12	16	4	33
Meteorology	1	2	1	100
Microbiology	168	181	15	8
Nutrition[2]	1	7	6	600
Pharmacology	7	3	-4	-57
Physical science	3	4	1	33
Physics	16	13	-3	-19
Physiology	73	83	10	14
Physiology	255	266	11	4
Soil science	165	173	8	5
Veterinary medicine	67	56	-11	-16
Zoology	13	8	-5	-38

[1]Where no change has occurred, discipline is omitted.
[2] These are nutritionists, ARS human nutrition researchers also include chemists, general biologists, and physiologists; also two of the five ARS human nutrition research centers employ many non-ARS scientists and physicians under contract or cooperative agreement.

Facilities Status

ARS currently has laboratory research facilities and field stations at 122 domestic and 7 foreign locations (see appendix A). Many of these, including five of its major locations (four regional research centers and the Beltsville Agricultural Research Center) are 50 years old or older. ARS' aging infrastructure is a significant problem for the agency, a problem that must be addressed aggressively with strategic planning.

The ARS real property inventory includes nearly 3,000 separate buildings and facilities that comprise about 12 million square feet of floor space. The current value of these and other capital improvements is estimated at $1.7 billion.

Many ARS laboratory facilities that were built in the 1940's and 1950's have reached or exceeded their useful service life and do not meet modern building codes and standards in terms of proper heating, ventilating, and air-conditioning systems and life safety requirements.

In a forward-looking mode, these facilities must also accommodate the technical demands of present and future high-technology research programs. Examples of improvements needed are containment facilities for biotechnology and biological control research.

ARS has already begun a modest program of facility renovation, replacement, and modernization using a combination of base program funding and special appropriated facility funds. Between 1987 and 1990, ARS allocated $106 million to facility improvements, an annual expenditure averaging $26.5 million.

These figures are shown in table 2.2, which also indicates that plans for ARS facility modernization expenditures through 1996 will require doubling the current average annual allocation.[1,2]

These plans are a continuation of the agency's significant start toward meeting its needs for infrastructure improvement. But additional strategies and plans must be developed to accelerate the systematic modernization of ARS facilities to maintain and enhance the agency's ability to carry out its mission. Careful planning is underway to compare the cost effectiveness of renovating existing facilities with that of total replacement using new construction. In any event, ARS priorities must be driven by program needs.

Most ARS projects for facility modernization are expected to be in the $5-$30 million range. But total modernization of several major ARS complexes is projected to be much higher. These include the Beltsville (Maryland) Agricultural Research Center, the National Center for Agricultural Utilization Research, Peoria, Illinois, the Southern Regional Research Center, New Orleans, Louisiana, the Western Regional Research Center, Albany, California, and the Plum Island Animal Disease Center, Greenport, New York.

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[1] Agricultural Research Service, Modernization Needs Over $1 Million, 1990. Prepared by Office of the Deputy Administrator for Administrative Management, Facilities Construction Management Division.

[2] USDA, Science and Education, July 1990. Agricultural Research Service FY '92 Agency Estimates.

Table 2.2. ARS Facilities Renovation and Modernization Status and Projections by Geographic Area

Area	1987-1990 R&M Expense		1991-1996 Projected R&M Expense	
	Total	Annual Average	Total [1]	Annual Average
	$1,000			
Beltsville	36,556	9,139	117,512	19,585
Mid South	7,934	1,983	15,972	2,662
Midwest	16,286	4,072	31,378	5,230
North Altantic	12,168	3,042	96,870	16,145
Northern Plains	5,979	1,495	8,165	1,361
Pacific West	12,926	3,232	24,928	4,155
South Atlantic	7,812	1,953	16,137	2,690
Southern Plains	6,429	1,607	43,654	7,276
Agency	106,090	26,523	354,616	59,104

[1] Agricultural Research Service, Modernization Needs Over $1 Million, 1990. Prepared by Office of the Deputy Administrator for Administrative Management, Facilities Construction Management Division.


6

Section III — Program Strategy—1992-1998

Introduction

The main purpose of this section is to document high-priority research areas for ARS during the 1992 to 1998 period. These research areas show how ARS plans to respond to high-priority problems identified by scientists, internal ARS program evaluation, clientele, new legislation, earmarked budget allocations, action and regulatory agency concerns, and executive branch initiatives.

The overall ARS base program, which addresses a much broader spectrum of problems facing U.S. agriculture, will continue to be the agency's mainstay. The ARS base program will be maintained and, where appropriate and feasible, strengthened.

One of the major sources of technical priorities reflected in this plan was the ARS National Research Leaders meeting held in Beltsville, Maryland, April 1990. More than 475 research leaders and other senior ARS staff assembled for discussion of problem identification and research needs across the full spectrum of ARS program responsibilities.

"Base Program Areas of Emphasis, 1992-1998," (below) of this section presents areas of research emphasis and planned outcomes according to ARS program objectives. These are areas of emphasis only, so many ARS research programs are not included in this discussion. "ARS Special Programs," p. 39, and "ARS Crosscutting Programs," p. 46, describe several special and cross-cutting (across various objectives) research programs that address science initiatives and broad problem areas of public concern.

Base Program Areas of Emphasis, 1992-1998

Objective 1. Soil, Water, and Air

Develop the means for managing and conserving the Nation's soil, water, and air resources for a stable and productive agriculture.

General Objectives 1998

To maintain and enhance the quality and productivity of the Nation's soil, water, and air resources through development of new and improved resource management practices and systems and to assess the long-term effects of agricultural activities and environmental changes on the quality and productivity of our natural resources.

The increasing productivity required of U.S. agriculture will depend on development of cost-effective technologies for improving the quality and productive capacity of our natural resources. Recent assessment suggests that we are rapidly reaching the limits of land and water supplies that can be developed economically.

ARS emphasis will be to expand research on water quality and global environmental change. This research will focus on effects of potential increases in temperature, carbon dioxide and other trace chemicals, and potential changes in hydrology and weather severity on crop yields, rangeland resources, and future water resources. Plans include expansion of the current research effort on water quality.

ARS will also increase emphasis on improving our understanding of the fate and transport of chemicals in agricultural ecosystems and on developing food and fiber production systems that use inputs more efficiently and are more protective of the environment. Other areas of increased effort include cost-effective waste utilization and development of integrated crop and livestock management practices and systems that reduce erosion, enhance efficient use of farm inputs, and maintain or increase the profitability and long-term productivity of agriculture.

The areas of emphasis in objective 1—Soil, Water, and Air—are based on the needs, priorities, and recommendations from several sources including advisory and coordinating bodies and user groups. ARS actively solicits their views through various means, including annual meetings, scientific and commercial forums, and direct communication of research needs. Cooperators in State and private universities are also important sources, as are professional organizations and international scientific bodies. Coordination of ARS and collaborative water quality research is provided through the USDA Working Group on Water Quality.

Priorities for research on water quality and the global environment are also integral components of the Committee on Earth and Environmental Science's Federal Ground Water Science and Technology Program and its U.S. Global Change Research Program. Priorities in soil erosion/productivity were identified in a major 1989 workshop of Federal, State, and university research and conservation leaders. In addition, a biennial report from the Soil Conservation Service lists that agency's soil and water conservation research and technology transfer needs. Information generated at meetings and workshops on research needs for natural resources has also been considered in developing this strategic plan.

Research Emphasis Area

Improved farming systems for reducing degradation of water quality by agricultural chemicals.

Planned Outcomes

1. Farming systems that use winter cover crops and crop rotations to minimize leaching of nitrate to ground water.

2. Improved guidelines for determining the timixng, rate, and method of application of organic and inorganic chemicals.

Research Emphasis Area

Strategies for offsite control of chemical buildup in ground water.

Planned Outcomes

1. Better understanding of nutrient transformation processes and loss rates below the crop root zone.

2. Guidelines for using shallow-water-table and wetlands management to increase pesticide degradation rates and decrease nitrogen losses to ground water.

3. Evaluation of the water quality benefits of well/aquifer protection.

Research Emphasis Area

Chemical application technologies for increasing fertilizer use efficiency and targeting pesticides to specific soil, crop, and pest conditions.

Planned Outcomes

1. New and improved methods for sensing variations in soil properties in fields.

2. Improved real-time control systems that can adjust farm equipment for spatial changes in soil and crop conditions.

3. Improved sensors and other techniques for monitoring pest populations.

4. More efficient pesticide application methods and pesticide formulations that minimize pesticide application methods and pesticide formulations that minimize pesticide volume, avoid nontargets, and reduce chemical mobility.

Research Emphasis Area

Evaluation and optimization of no-till and other conservation tillage and residue management systems to increase soil organic matter, infiltration, and soil biological activity and to reduce runoff, erosion, evaporation, and drought damage.

Planned Outcomes

1. Increased use of no-till and other conservation tillage systems, attendant reductions in erosion and compaction, and increased organic matter and productive potential.

2. Guidelines for determining which combination of tillage treatment, chemical and organic amendments, and crop variety has the most potential for increasing the depth of rooting.

3. New and improved equipment, practices, and farming systems for increasing the efficient use of precipitation.

4. Improved strategies for mitigating the effects of prolonged drought on agricultural production.

Research Emphasis Area

Technologies for improving productivity of cropland through use of municipal and industrial wastes.

Planned Outcome

Guidelines for safe and economic use and disposal of municipal and industrial wastes on agricultural lands to improve infiltration rates, water storage capacity, plant rooting depth, and drought tolerance.

Research Emphasis Area
Technologies for delineating land areas vulnerable to soil and water degradation.

Planned Outcomes

1. Improved models for predicting how changes in global environment and in agricultural management practices will affect water and wind erosion and chemical loss below the root zone.

2. Water quality models for predicting movement of agricultural chemicals, salts, and sediments into streams, lakes, and aquifers.

3. Guidelines and technologies for monitoring critical variables required by models used to assess conditions of the agroecosystem as a part of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP).

Research Emphasis Area
New methods for assessing effects of global environmental change on water and energy fluxes and water resources.

Planned Outcomes

1. Improved models of snowmelt runoff for use in predicting amounts and seasonal distributions of downstream waterflows.

2. More realistic estimates of precipitation, evapotranspiration, and reflectivity for use in general circulation models.

3. More accurate and reliable methods for predicting precipitation changes resulting from environmental change and large-scale atmospheric circulations.

4. Remote-sensing techniques to monitor seasonal changes in the soil water content of rangelands and to assess the potential impact of global change on range productivity, forage establishment, and ground water recharge.

5. Improved methods for assessing the economic consequences of an increase in frequency and severity of droughts resulting from climate change.

Research Emphasis Area
Methods for quantifying agriculture's contribution to fluxes of greenhouse gases to and from the atmosphere.

Planned Outcomes

1. Improved measurements of terrestrial carbon and nitrogen balance that contribute to improved predictions of greenhouse gas fluxes to the atmosphere.

2. Improved models to predict how global change and land management strategies might affect changes in atmospheric greenhouse gases.

Research Emphasis Area

Methods for measuring what impact global environmental change would have on the health and sustainability of agroecosystems.

Planned Outcomes

1. Improved measurements of plant response to higher levels of carbon dioxide in the atmosphere.

2. Measurements of plant response to tropospheric ozone and radiation quality.

3. Improved models for predicting how environmental change would affect sustainability of agroecosystems.

Research Emphasis Area

Erosion control practices for conditions where amount of crop residue is low.

Planned Outcomes

1. New and improved methods for using vegetative barriers to reduce wind-shear stresses at the soil surface.

2. Improved management systems based on crop rotations and use of available waste materials for reducing wind and water erosion.

Research Emphasis Area

Methods of planting, weed control, harvesting, and residue management that will facilitate conservation tillage, including no-till systems.

Planned Outcome

Increased use of no-till and other conservation tillage systems, attendant reductions in erosion and compaction, and increased organic matter and productive potential.

Objective 2. Plant Productivity

Develop means to maintain and increase crop productivity and maintain and improve the quality of crop plants.

General Objectives l998

To focus and balance research to ensure maintenance of U.S. crop production capacity and produce solutions to emerging problems, including: production sector profitability, U.S. competitiveness in the global market for agricultural products, environmental and ecological compatibility of agronomic practices, fundamental barriers that limit crop productivity, and potential effects of pests and environmental stress during production.

Production agriculture is at a crossroads. Overall, peak productivity has not been reached, but even if low producers were brought to the production level of high producers, natural barriers to overall higher productivity exist. Productivity gains for plants of economic value have leveled off because of genetic and physiological barriers. In turn, many more producers are reaching maximum productivity because:

- Production sector profits, particularly for small producers, are faltering.

- Competition in global markets is intensifying.

- Production costs increase as new standards of safety and environmental compatibility must be met.

- Shifts in traditional agricultural production geography and demographics may result from environmental climate changes and regional water availability.

There are two possible research strategies: One is to assume a defensive posture and to direct research to protecting current capacity and capability. The other is to bring all of the emerging technological capability that can be mustered to bear on long-range research strategies to meet future challenges. ARS' strategy is to seek a balance between the long-term and immediate needs. The emerging technologies are targeted towards retention and increase of U.S. technological leadership. The areas of emphasis presented below reflect this balanced strategic framework.

The areas of emphasis in objective 2, Plant Productivity, are based on the needs, priorities, and recommendations of many organizations and advisory groups representing agronomic and horticultural producers and universities, as well as broader industry associations. ARS actively solicits their views in both formal and informal consultations involving headquarters staff and ARS scientists. In addition, Federal agencies such as the Animal and Plant Health Inspection Service and the Soil Conservation Service regularly communicate their research needs to ARS.

The National Biological Control Program uses a series of biological control working groups to obtain recommendations on research priorities and policy issues. Coordination with other USDA agencies is maintained through the Interagency Biological Control Coordinating Committee. Frequent interaction with action agencies, commodity user groups, and other clientele provides a focus on high-priority pests.

Plant germplasm program priorities are consistent with the 1990 Farm Bill related to the new National Genetic Resources Program and responsive to recommendations of the

National Plant Genetic Resources Board, the International Board for Plant Genetic Resources, and the United Nations' Food and Agriculture Organization. The Plant Genome Research Program establishes priorities based on recommendations of the Plant Genome Coordinating Committee, which represents industry, government, and academic scientists, the National Institutes of Health, the National Science Foundation, and major international genome mapping centers.

Research Emphasis Area

Enhancement of plant germplasm by manipulating the plant genome at the molecular level, including development of more efficient methods of genetic improvement and technical methods for genetic transformation of a broad range of economic plants. Lack of such methods has slowed progress.

Planned Outcomes

1. Genetic probes to locate desired genes, tissue-specific promoters, and regeneration systems for economically important species, emphasizing overcoming major barriers to routine transformation of major field and horticultural crops.

2. Broad-based genome maps for economically important species.

3. Improved cultivars for producing more marketable product per unit of land and input.

Research Emphasis Area

Acquisition, evaluation, and enhancement of plant genetic resources and development of improved varieties using various approaches (traditional, molecular, genetic, and combinations) to overcome productivity barriers in major crops.

Planned Outcomes

1. A comprehensive genetic resources program.

2. Improved varieties with resistance to plant pathogens, insects, and nematodes and resistance to and ability to compete with weeds.

3. Improved varieties with increased tolerance to environmental stress, including water, temperature, air pollution, and salinity.

4. Improved major crop varieties with superior market quality and nutritional value.

5. Alternative crops for industrial uses and as energy or strategic material sources.

Research Emphasis Area

Computer simulation models for weed detection and growth and development of economically important crops and weeds.

Planned Outcomes

1. Computer simulation models to be used as decision aids for more efficient management of major crops.

2. Research models to identify gaps in knowledge, to understand biological limiting factors, and to help in setting research priorities.

Research Emphasis Area

Research to develop diverse technologies for controlling fundamental biological processes related to plant productivity, market quality, and reduction of unit production costs.

Planned Outcomes

1. Means to regulate gene expression at molecular level related to increase in productivity, stress tolerance, pest resistance, and control of photosynthate distribution for major crops.

2. Identification of physiologically active, naturally occurring compounds or derivatives for use in crop production systems to regulate biological processes related to productivity, quality, stress tolerance, and pest resistance.

Research Emphasis Area

Development of a relational database for the National Plant Germplasm System. Needed to speed response and expand access for breeders and other users.

Planned Outcome

Operational database with capability of viewing complete information on a plant accession and linkage to GRIN for genetic stock collections and plant symbiotic and plant parasitic microorganisms.

Research Emphasis Area

New technology for long- and short-term preservation of seed, pollen, and other forms of plant germplasm.

Planned Outcomes

1. New technologies for conventional and recalcitrant seeds.

2. Improved simple methods for pollen storage and transport.

3. Growth-retarding tissue culture media for field and orchard collections.

4. Reduced excessive regeneration needs and facilitated introduction and exchange.

Research Emphasis Area

Research to expand molecular technologies for detecting pathogens in propagative material. Needed to prevent introduction of foreign or exotic pests and to reduce losses resulting from such introductions.

Planned Outcomes

1. New and improved pathogen detection methods based on biotechnology.

2. Technology for eliminating pathogens.

3. Means to reduce production losses due to introduced pathogens.

Research Emphasis Area

Nondestructive methods to test seeds for viability and composition, and computer graphics (digitized) means to evaluate results of destructive germination tests.

Planned Outcomes

1. New nondestructive methods.

2. Physiological knowledge required for methods.

3. New digitized scanning technologies useful for semi-automated testing.

Research Emphasis Area

Research on production systems for florist, nursery, and other high-value, low-acreage horticultural and specialty crops.

Planned Outcomes

1. Improved opportunities for small farm operators.

2. Improved opportunities for integration of high-value, low-acreage crops with existing production systems.

3. Reduced imports of horticultural and specialty crops—especially florist and nursery crops—now needed to supply a greatly expanding domestic market.

4. Increased availability and reduced cost of landscape and environmental plants needed in expanding suburban areas.

Research Emphasis Area

Filling gaps in knowledge for application to pest control systems. Needed to identify ecologically vulnerable points for systems development and to avoid disrupting ecosystems.

Planned Outcomes

1. Data on biochemistry/metabolism of crop and weed susceptibility and tolerance to herbicides.

2. Data on economic-threshold populations of weeds in conservation and no-till systems.

3. Data on mechanisms governing behavior and biology of major pests and beneficial insects.

4. Methods for successful gene transfer in pests, beneficial insects, and microbial biocontrol agents.

5. Data applicable to controlling pests through biological processes related to interactions within and among major insect pest species.

Research Emphasis Area

New pest control methods that are environmentally safe and have acceptable health risks.

Planned Outcomes

1. New methods for production, formulation, and application of biocontrol agents.

2. New technology for use of pheromones, autocidal methods, and disruptive bioregulators in major insect pest control systems.

3. Identification and development of naturally occurring compounds and pathogens for use in weed control systems.

4. New safe technologies for eliminating accidentally introduced fruit flies and other pests.

5. New, nonsynthetic chemical pesticides to eliminate pests from export commodities.

6. New, improved technology for formulation and application of pesticides.

7. Safe and effective methods of controlling pests on minor and specialty crops.

Research Emphasis Area

Improved methods for the safe and efficacious management of major insect pests in the urban environment.

Planned Outcomes

1. New methods for the management of cockroaches and fleas in and around the home that reduce dependence on pesticides.

2. Development of integrated management strategies for the control of pest ant species in the urban environment.

Research Emphasis Area

Areawide management systems for control of high-priority pests. These systems would be environmentally safe and have acceptable health risks and would include methods to apply effective rates of chemical pesticides at lower levels. Needed to reduce reliance on traditional chemical control.

Planned Outcomes

1. New areawide systems for control of bollworms and budworms (*Heliothis* spp.), boll weevils, adult corn rootworms, pink bollworms, and common larval vegetable crop pests like cabbage loopers and diamondback moths.

2. Models to help in making decisions about pesticide applications.

3. New economical, ecologically compatible pesticide formulations and application methods.

4. Improved systems for weed and plant disease management.

5. Total postemergence weed control systems.

6. Risk/benefit assessment of pesticides essential to crop productivity.

Research Emphasis Area

Management systems that provide for sound ecosystem maintenance and efficient water use on important range, pasture, and crop lands.

Planned Outcomes

1. Ecologically compatible production system models.

2. Demonstrated feasibility of incorporating legumes and crop residues into production systems that include pasture and range lands.

3. Water-efficient models for production systems in arid and semi-arid regions.

Objective 3. Animal Productivity

Develop the means for increasing animal productivity and the quality of animal products.

General Objectives 1998

To increase animal productivity through genetic selection and manipulation, disease and parasite control, and improved efficiency of feed utilization and to reduce the potential for microbial contamination of animal products.

Animal productivity is influenced by several factors, including genetic makeup, reproductive efficiency, health, and nutrition. The quality of food derived from animals relates not only to nutrient composition of the product, but also to freedom from microbial contamination. Major emphasis will be placed on identifying genes or groups of genes that influence factors such as growth, reproduction, carcass and milk composition, egg production, and resistance to diseases and parasites. Gene maps will be developed for important characteristics in the economically significant agricultural species. Regulation of gene expression is the goal for research that analyzes specific regulatory genes and gene families and characterizes genetic variants that influence desirable traits.

In an effort to develop new and improved methods for preventing losses from diseases and parasites, research will emphasize recombinant nucleic acid technologies; also, fundamental research will be expanded on gene expression and delivery systems and on the immunology of food animal species. Methods will be sought to control zoonotic bacteria and parasites in the live animal in order to reduce food product contamination. A major effort will be made to develop biologically based control methods for internal and external parasites to replace or reduce chemical use. Fundamental studies on food utilization, growth, and body composition will continue.

The areas of emphasis in objective 3, Animal Productivity, are based on the needs, priorities, and recommendations of a variety of organizations and advisory groups associated with animal agriculture. ARS actively solicits their views in consultations involving headquarters staff and ARS scientists. Priority setting within objective 3 is the result of frequent interactions with organizations representing beef, dairy, pork, sheep, and poultry producers, as well as broader industry associations such as the Forum for Animal Agriculture and the U.S. Animal Health Association. Cooperators in State and private universities are also an important source, as are professional organizations and international scientific bodies. In addition, Federal agencies such as USDA's Animal and Plant Health Inspection Service and Food Safety and Inspection Service and the Department of Defense regularly communicate their research needs to ARS.

Research Emphasis Area

Research to increase the genetic capacity of animals for greater production.

Planned Outcomes

1. Gene maps of important characteristics for food animal species.

2. Identification of quantitative trait loci that influence growth and reproduction.

3. Identification of specific genes, or factors that regulate genes of interest, and gene families and genetic variants that influence desirable traits.

4. Cryopreservation and other technologies required to preserve embryos, gametes, and stem cells of superior and rare animal species.

5. Marker-assisted genetic selection.

Research Emphasis Area

Means to improve, at the molecular level, genetic resistance of animals to diseases and internal and external parasites.

Planned Outcomes

1. Identification of genes and gene markers for disease-resistant characteristics.

2. Characterized organization and regulation of genes associated with specific disease resistance.

3. Characterized immune mechanism by which genes influence disease resistance.

4. New and improved systems for gene expression and delivery for in vivo applications such as gene therapies and production of genetically altered animals.

Research Emphasis Area

New and improved methods for preventing or reducing death, morbidity, and other losses from disease and parasites.

Planned Outcomes

1. Recombinant nucleic acid technologies for more effective vaccines and rapid, sensitive diagnostic tests.

2. Expanded knowledge of the immune system of food animal species, as needed, to develop methods to manipulate the cellular and humoral immune responses.

3. Optimum systems for immunogen presentation and delivery.

4. Characterized replicative processes and molecular structure of animal viruses, as needed, to develop novel (nonvaccine) means for disease control.

5. Characterized cellular and molecular events in the pathogenesis of certain animal diseases.

6. Identified and characterized genes related to virulence of major infectious agents.

Research Emphasis Area

Methods for biologically based control of internal and external parasites to reduce dependence on chemically based management programs.

Planned Outcomes

1. Useful biocontrol agents and procedures for biological control of insects, ticks, and mites that affect farm animals.

2. Applied quantitative ecology, modeling, and population genetics for development of management techniques that minimize use of chemicals to control arthropods, helminths, and protozoa of veterinary and medical importance.

3. New means to augment the immune response to control internal and external parasites of food animal species.

4. Characterized genetic basis for transmission of disease-causing organisms by arthropods.

Research Emphasis Area

Improved knowledge of physiological processes involved in feed intake and metabolism to promote better growth, lactation, egg production, and fetal development.

Planned Outcomes

1. Identified factors that influence metabolism of nutrients in relevant tissues.

2. Improved techniques to measure protein degradation in farm animals.

3. Increased knowledge of how maternal nutrient status affects embryonic development, early growth, and subsequent performance of offspring.

4. Identified factors that influence feed selection and regulate feed intake as a basis for controlling growth rate and chemical composition of product.

Research Emphasis Area

Delineation of the mechanisms by which chemical and physical composition of feed limits availability of nutrients needed to obtain maximum animal productivity.

Planned Outcomes

1. Knowledge of structural carbohydrates and lignin complexes in plant cell walls needed to be able to increase nutrient availability and productive function.

2. Sufficient knowledge of feed plant attributes to augment microbial hydrolysis of structural carbohydrates, raise microbial protoplasm yield, and decrease losses.

Research Emphasis Area

Development of nondestructive techniques for repeated measurements of body composition.

Planned Outcomes

1. Quantitative methods to measure metabolism of nutrients in relevant tissues.

2. Methods to serially monitor the influence of maternal nutrient status on the embryo/ fetus.

3. Means to select breeding animals of desirable body composition.

Research Emphasis Area

Development of methods to control zoonotic bacteria and parasites in the live animal to reduce the potential for contamination of food products.

Planned Outcomes

1. Characterized mechanism by which zoonotic bacteria colonize the intestinal tract; knowledge will be used to develop intervention strategies.

2. Characterized epidemiology of zoonotic bacteria and parasites to determine management factors that can be manipulated to reduce exposure and transmission.

Research Emphasis Area

Conduct interdisciplinary aquaculture research to improve efficiency of production.

Planned Outcomes

1. Improved production systems to control flavor of catfish and other species that are intensively cultured.

2. Improved production systems for lower levels of nutrient output in effluents.

3. Improved methods of genetic selection for economic and disease-resistant traits of catfish.

Research Emphasis Area

Conduct research on animal behavior, physiological indicators of animal well-being, and production efficiency to improve well-being and humane care of farm animals in production facilities.

Planned Outcomes

1. Increased knowledge on relationships among behavior, physiological indicators, and production efficiency of farm animals.

2. Measurement of animal well-being.

3. Management practices for improved animal well-being and humane animal care.

4. Production facilities and systems optimized for improved animal well-being and humane care.

Research Emphasis Area

Development of means to use animal wastes and means to reduce waste contamination of surface and ground water.

Planned Outcomes

1. Alternative systems for storage and application of wastes to the land for efficient nutrient preservation and use by crops.

2. Control of gaseous emissions.

3. Improved odor and fly control.

4. More accurate information on feed nutrient composition to reduce nutrient excretion.

5. Systems to more efficiently produce and use methane.

6. Methods to improve forage protein use in ruminants.

7. Management strategies for disposal of animal wastes on pasturelands. Knowledge of the effects of waste on surface and ground water, forage production, animal health, and animal safety.

8. Management practices for manure disposal to reduce fecal contamination of streams.

9. Cropping and animal waste systems for improved cropland and rangeland management.

Objective 4. Commodity Conversion and Delivery

Develop means to enhance the quality and use of agricultural materials to meet domestic and global market demands.

General Objectives 1998

To maintain and improve the economic viability and competitiveness of U.S. agriculture by improving quality and performance of commodities, by meeting consumer and regulatory safety criteria, by devising environmentally benign, safe processing concepts, and by expanding domestic and global market opportunities through development of value-added food and nonfood products.

Continued profitability of U.S. agriculture will depend on the competitive position of U.S. food, feed, and industrial products and commodities in what is now a global market. This program area extends well beyond the handling and processing efficiency of harvested commodities. It deals with natural and introduced toxicants; the nutrient, aesthetic, and performance properties of commodities and products; trade barriers; and greater utilization through new, value-added products, which is critically important to the U.S. trade balance, rural development, and farmer return.

Several market trends and factors were considered in developing the areas of research emphasis. They include:

- Entry of new global competitors into traditionally U.S. dominated markets—grains, for example.

- Formation of the European Community Common Market in 1992—a market opportunity for U.S. value-added products and not a market loss.

- Rapidly escalating domestic and export (particularly Pacific Rim) demand for fresh fruits and vegetables.

- Increasing regulatory and consumer (domestic and export) concern about food safety and health.

- Emergence of quality, uniformity, and convenience as major marketability factors.

- Growing need for fast, accurate, and nondestructive methods of determining the quality and grade of commodities.

- Projected changing economies of the petrochemical-based organochemical and energy industries.

ARS emphasis will be to expand research on food safety and utilization. This research will focus on a systems approach (preharvest and postharvest) to solution of the critical food safety problems of foodborne pathogenic organisms and mycotoxins. Plans for increased utilization will emphasize use of bioprocessing and systems engineering in development of value-added industrial products, alternatives to fuels and imports, and environmentally benign products and processes.

ARS will also increase research emphasis on quality enhancement of U.S. agricultural commodities and products through identification of the compositional determinants of

end-use performance and development of rapid, objective methods for safety and quality criteria, physiological control methods to extend shelf life, and integrated approaches to eliminate trade barriers.

The areas of emphasis in objective 4, Commodity Conversion and Delivery, are based on the needs, priorities, and recommendations of many organizations and advisory groups associated with postharvest issues of quality, safety, export trade barriers, and new process and product development to enhance utilization. ARS actively solicits the views of these groups through various means, including annual meetings, scientific and commercial forums, and direct communication of research needs. Frequent interactions with national commodity organizations for wheat, soybeans, cotton, corn, peanuts, fruits, vegetables, and poultry and the associated organizations for food, feed, fiber, and leather processing and export provide an extensive body of information on future needs.

This information is integrated with economic and marketing data acquired from USDA's Economic Research Service and Foreign Agricultural Service, departments of economics and marketing at universities, and private industry. The National Program Staff, in concert with ARS scientists, then derives program priorities by evaluating this information against the framework of the ARS mission and responsibilities and the needs of USDA action agencies, such as the Food Safety and Inspection Service, the Federal Grain Inspection Service, and the Agricultural Marketing Service.

Research Emphasis Area

Means to prevent or eliminate foodborne pathogenic microbial contamination of meat and poultry products.

Planned Outcomes

1. Control measures based on technologies for modifying gut microflora in newly hatched and growing poultry.

2. Integrated processing systems that achieve effective control.

Research Emphasis Area

Means to prevent mycotoxin contamination of food products.

Planned Outcomes

1. Plant germplasm resistant to invasion by mycotoxin-producing fungi.

2. Practical means to disrupt the mycotoxin production cycle.

3. Biocontrol agents for fungal infection.

4. Agronomic practices designed to avoid mycotoxin formation in major mycotoxin-prone crops.

5. Revised storage/transport practices to avoid postharvest mycotoxin production.

Research Emphasis Area

Means to eliminate agricultural commodity and product trade barriers based on insect or disease infestation.

Planned Outcomes

1. Practical safe technologies for fumigation of TCK and other disease organisms.
2. Improved methods for in-transit fumigation that minimize chemical use.
3. Improved commodity treatments that combine physical and chemical methods and maintain quality.

Research Emphasis Area

Means to meet grain market requirements for desired physical, sanitary, and performance characteristics within a designated range in uniformity.

Planned Outcomes

1. Identification of relationships among composition, molecular structure, physical state, and end-use performance.
2. Identification of grain components and their regulator genes relevant to performance.
3. Plant germplasm resistant to change induced by temperature stress in those components relevant to performance.
4. Plant germplasm with improved performance characteristics.
5. Migration/growth models to be used in models for major stored-grain insects.
6. Control measures for stored-grain insects using physical and biocontrol technologies or chemicals that disrupt life cycles.
7. Integrated management systems incorporating a combination of the best treatments for pest control.

Research Emphasis Area

Means to extend shelf life and provide desired sensory quality in agricultural commodities.

Planned Outcomes

1. Identification of molecular events controlling texture during ripening and sensitivity to chilling in fruits and vegetables.
2. Identification of molecular events controlling flavor development and degradation.
3. Genetic lines that provide extended shelf life and desired flavor.
4. Biocontrol agents to reduce or eliminate losses caused by postharvest disease.
5. Micro-controlled atmospheric storage regimens to minimize postharvest disease, optimize quality, and reduce energy costs in transport.

Research Emphasis Area

New and improved methods for rapid, cost-effective analyses of chemical and toxic residues in food.

Planned Outcomes

1. Reduction in time needed to develop methods for new residue problems through use of predictive models based on relationship of structure to activity.

2. Biological detectors that balance specificity and inclusiveness better than current methods.

3. Alternative methods of extraction and analyses that minimize solvent use and toxic waste development.

Research Emphasis Area

Interactive sensors and nondestructive methods for rapid, objective, cost-effective analyses of quality characteristics important to marketing.

Planned Outcomes

1. Implementation of instrument-based grading technology for all cotton properties important to the textile industry.

2. Implementation of objective classification system for wheat.

3. Rapid methods for assessment of intrinsic properties in grains.

4. Nondestructive measurement of fruit, vegetable, and nut maturity.

5. Objective grading system for the wool market.

6. Objective odor assessment in grains.

Research Emphasis Area

Value-added industrial products from agricultural commodities and residues.

Planned Outcomes

1. Improved biodegradable plastic films and injection-molded consumer products from cereal starch.

2. Starch-based encapsulation materials for microbial biocontrol agents and chemical pesticides to improve their effectiveness and reduce potential environmental damage.

3. Biopesticide products from bioprocess (microbial and cellular technologies) engineering systems using starch as feedstock.

4. High-value chemical specialty products from vegetable oils, starches, and dairy lactose.

5. Natural biopolymers derived from agricultural commodities to provide new biomaterials (copolymers, composites, derivatives).

6. Byproducts from tannery solid wastes.

7. Bioprocesses for production of alternative fuels and industrial chemicals.

Research Emphasis Area

New value-added food products from agricultural commodities.

Planned Outcomes

1. Natural food flavors, colors, preservatives, and texturizing agents.

2. Fat substitutes.

3. New processed food products, with more value added before export, to meet foreign consumers' needs.

4. New domestic food products to meet desires for better nutrition, wholesomeness, and convenience.

5. Milk protein and butterfat products with unique performance characteristics in food systems.

6. Health-promoting, high-dietary-fiber extruded products made from a combination of grain and fruits.

7. Partially processed vegetables that retain fresh texture and color characteristics.

8. Technologies to extend product diversity, processing season, and final processing location for seasonal fruits.

Research Emphasis Area

Development of new or improved fiber and hide products and technologies to meet domestic and export market opportunities.

Planned Outcomes

1. New machinery and process control systems and new cleaning and drying technology that is less stressful to fiber quality.

2. Expert models for cotton ginning.

3. Increased cotton fiber strength, rivaling that of polyester and shown to be economically practical.

4. More resilient cotton yarns for use in cotton carpeting and apparel.

5. Low-cost, nontoxic, formaldehyde-free flame-retardant cotton products for children's nightwear and for protective clothing.

6. Practical nonwoven fabric products based on cotton.

Research Emphasis Area

Process treatments with integrated technologies to enhance food safety, retain quality, and minimize additives.

Planned Outcomes

1. Development of databases and computer models for predicting influence of food component interactions on growth of foodborne pathogens.

2. Expansion of existing databases and computer programs designating safety processing practices to cover a broader product and bacterial spectrum.

Research Emphasis Area

Alternative, environmentally benign process and product technologies.

Planned Outcomes

1. Processes that minimize or replace brine as a medium for curing cattle hides and reduce or replace chromium in tanning as mandated by the Environmental Protection Agency.

2. Pickling processes that reduce brine requirements for cucumbers and cabbage.

3. Tested technology for reducing effluent volume from cotton-textile finishing plants.

4. High-quality, formaldehyde-free permanent press cotton and cotton blend fabrics.

Objective 5. Human Nutrition and Well-Being

Develop the means for promoting optimum human health and well-being through improved nutrition and family resource management.

General Objectives 1998

To obtain information on human dietary requirements, methods for assessing nutritional status, food composition, and utilization of foods, needed by producers, processors, and educators to make available a nutritionally adequate supply of wholesome foods from which consumers can readily select a healthful diet.

Today, consumers are concerned about how the foods they eat affect their health. Though the era of nutritional deficiency diseases is behind us, our ability to detect marginal inadequacies or borderline toxicities is very poor. New problems of dietary excess and imbalances have appeared along with concerns about the role of diet in the onset of some forms of cancer.

Consumers are concerned about the more elusive aspects of diet, such as the effect on their heart, intellect, physical performance, risk of chronic disease, and lifespan. Nutrition does influence the expression of our genetic potential, and diet commonly stimulates regulatory hormones, which influence gene expression and the metabolic pathways involved.

To provide the information needed, appropriate studies of the effects of the various nutritional components must be done with human subjects. Database on the composition of foods consumed in important amounts, including information about their bioavailability in mixed diets, is also required. Without adequate information, producers, health professionals, educators, and consumers will be unable to provide or select appropriate foods for diets to maintain health and well-being.

The components of the ARS strategic plan in objective 5, Human Nutrition and Well-Being, are based on interactions with several advisory and coordinating bodies and user groups. The ARS research areas are part of the USDA Comprehensive Plan for a National Food and Human Nutrition Research and Education Program, formulated at the request of Congress in 1986. This comprehensive plan, prepared with the help of the Subcommittee for Human Nutrition of USDA's Research and Education Committee, was structured in turn to fit into the Federal 5-Year Plan—a Human Nutrition Research Plan developed by the Interagency Committee on Human Nutrition Research. Continued interactions with these and other human nutrition research coordinating committees have provided input for the ARS 6-year plan.

In addition, the Human Nutrition Board of Scientific Counselors, an advisory body to the Secretary of Agriculture, through a Working Group on Research, has reviewed the ARS strategic plan and made recommendations for changes. These suggestions, as well as the needs of industry, user, and several liaison groups, have been considered in developing the areas of emphasis in this implementation plan.

Research Emphasis Area

Methods to determine, and expand information about, composition of foods. To devise healthful diets, reliable composition data are needed for several nutrients and other phytogenic (plant-derived) components (such as fibers, anticarcinogens, and antioxidants) in many commonly consumed foods.

Planned Outcomes

1. Suitable methods for sampling and assaying foods for different species of nutrients and their bioavailability.

2. Information on range of levels of those phytogenic substances in food that have anticarcinogenic and other healthful effects for consumers and producers.

3. Nutrient composition values needed to complete Agriculture Handbook 8 for those foods that provide important amounts of nutrients.

Research Emphasis Area

Clarify role of dietary components on weight maintenance and risk of chronic diseases. Prevention of obesity and modification of diet to reduce risk of 5 of the top 10 lethal diseases is critical to consumer health.

Planned Outcomes

1. Information about how fatty acid types, levels, and ratios in diets affect (a) people on weight maintenance and (b) specific risk factors for chronic disease.

2. Understanding of how physiological function of complex carbohydrates and dietary fiber components affect (a) weight maintenance and (b) risks associated with chronic disease.

3. Information about the roles of calcium, vitamin D, magnesium, zinc, and boron in maintaining bone density and preventing osteoporosis.

4. Understanding the mechanism of the interaction between dietary fructose and low dietary copper and the role of antioxidant food components in reducing damage from metabolically induced free radicals and risk of chronic diseases.

Research Emphasis Area

Defined adequate and safe ranges of intake for nutrients and energy (calories) for humans. Reliable information is essential for developing appropriate foods, monitoring nutritional health of the population, and educating consumers about diet. Individual variation of nutrient requirements related to age, genetics, gender, activity, and so on, is necessary to establish standard distribution curves of the population to interpret nutrient intake data.

Planned Outcomes

1. Knowledge about nutrient needs of infants (especially those with low birth weight) for normal growth and development.

2. Information about how the diet of the pregnant woman, especially the teenage mother, affects her health and that of her developing baby.

3. Information about the dietary needs of adolescents, other than that obtained by extrapolation from trials with adults.

4. Information about the effect of foods and nutritional adequacy on behavior and performance, especially in the very young and the elderly.

5. Increased knowledge of nutritional needs of the elderly and of the effect of nutritional status on aging.

6. More sensitive methods for evaluating nutritional status, suitable for use in surveys.

Research Emphasis Area

Strategies for changes in food production and processing systems to enhance nutritional qualities of foods for consumers.

Planned Outcomes

1. Nutritionally improved animal food products with lower levels of total fat and saturated fatty acids and appropriate fatty acid balance and improved dairy foods with lower lactose/galactose.

2. Nutritionally improved plant foods, especially with respect to iron, dietary fiber components, antioxidants, antinutrients, and other phytogenic substances of health significance.

Objective 6. Systems Integration

Areas of emphasis for systems integration are included under objectives 1 through 5 in cases where integrative systems approaches are appropriate. Integrative systems research aimed at more general goals—such as developing systems engineering capability for the agency—will be a critical component of planning and setting priorities for related implementation strategies.

Special Programs

Historically, ARS has been USDA's lead agency for special research programs. These programs usually have clear-cut technical objectives; involve cooperation with USDA or other Federal agencies, universities, and industry; and have earmarked funding or funding targets. Examples of major special research programs to be undertaken from 1992 to 1998 are the Plant and Animal Genome Programs, the Global Environmental Change Research Program, and the Utilization Research Program.

Each has a high priority, a broad technical scope, and is at an early stage in program development.

ARS Plant Genome Program/Animal Genome Program

ARS Plant Genome Program

General Goal. Facilitate improvement of plants by locating important genes and markers on chromosomes, determining the structure of those genes, and manipulating them and their regulators to improve performance to meet market needs without harming the environment. This special research program will seek to achieve its objectives through complementary extramural and intramural efforts. Extramural participation in the research will require a heavy involvement of university and industrial researchers. Because technical developments and research progress are taking place so rapidly, we must concentrate on improving data integration and dispersal within a network of diversified participants. Major research directions are:

- Gene construction for broad genetic similarities and differences; the goal is gene maps for several major crop species.

- Gene construction for important economic traits—including yield, heat or cold tolerance, and disease or pest resistance—of major species for which some data already exist; the goal is to complete partial and total sequencing of important gene systems.

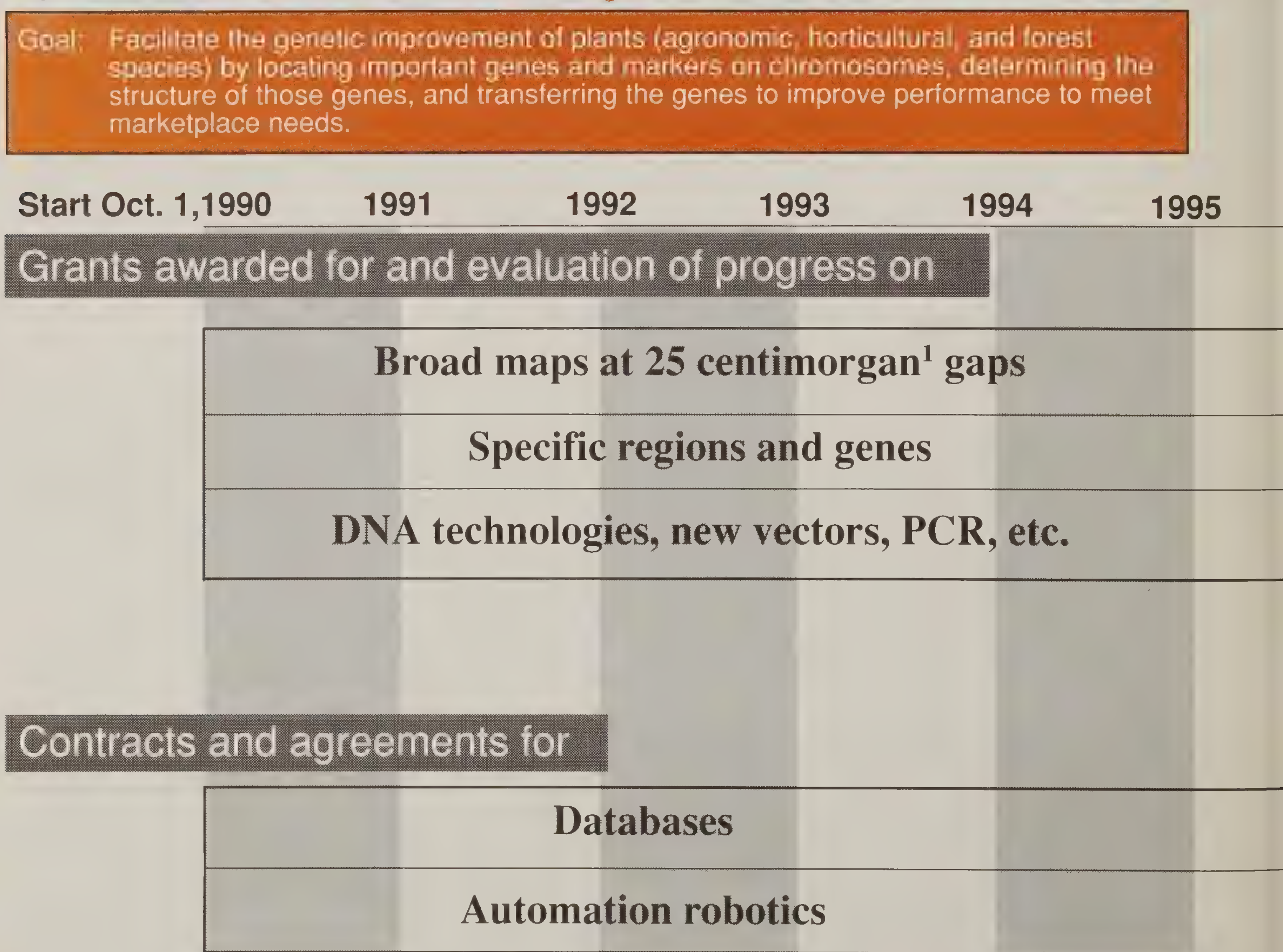
- Development of new mapping and sequencing technologies.

- Development of automated technical information systems and technological laboratory procedures for electronic data gathering and exchange, coordinated with hardware and software development.

- Development of robotics and automation of molecular and biological techniques for DNA procedures.

Timetables, processes, and milestones for achievement of these goals are presented in figure 3.1.

Figure 3.1. Plant Genome Research Program



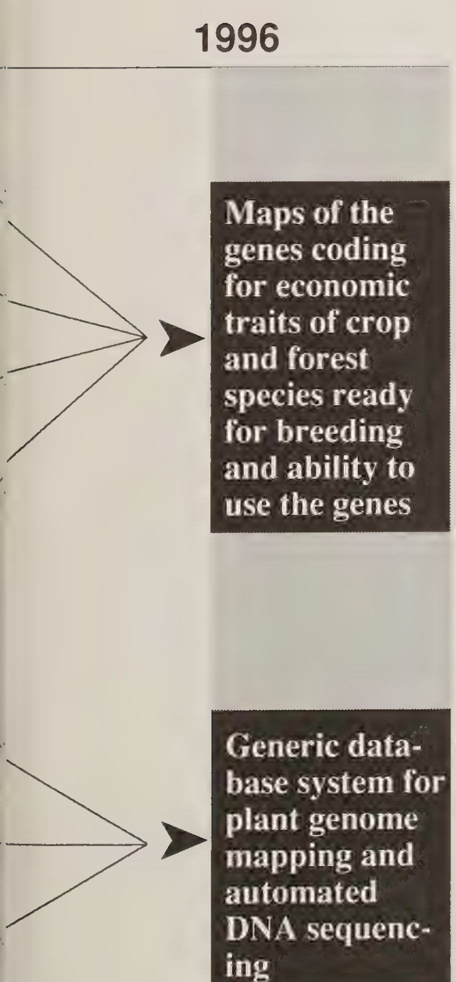
[1]Centimorgan is a common measurement in gene mapping.

ARS Animal Genome Program

General Goal. Improve animal health and performance and quality of animal products by locating important genes and markers on chromosomes, identifying genes associated with traits related to production efficiency and disease resistance, and manipulating genes and their regulators.

This special research program will seek to achieve its objectives through intramural and cooperative extramural efforts. Extramural participation in the research will require a closely coordinated national effort with State agricultural experiment stations and industrial research participants in the program. As with the plant genome program, because the rate at which data are being generated is so rapid, we need to concentrate on improving data integration and dispersal within a network of diversified participants. This will accelerate the rate at which new information becomes available to all researchers. Some research directions are:

- Gene mapping to identify broad genetic similarities and differences among farm animals and humans and among the animals within species; the goal is to develop gene maps for the major food-producing animal species.
- Identification and structural analysis of genes to single out important economic traits, such as reproductive performance, use of nutrients, yield of low fat, yield of high protein, and disease or pest resistance of major species; the goal is total sequencing of important gene systems.
- Development of new mapping and sequencing technologies leading to rapid screening systems that will identify animals with important economic traits.
- Development of automated technical information systems and technological laboratory procedures for electronic data gathering and exchange, coordinated with hardware and software development.



ARS Global Environmental Change Research Program

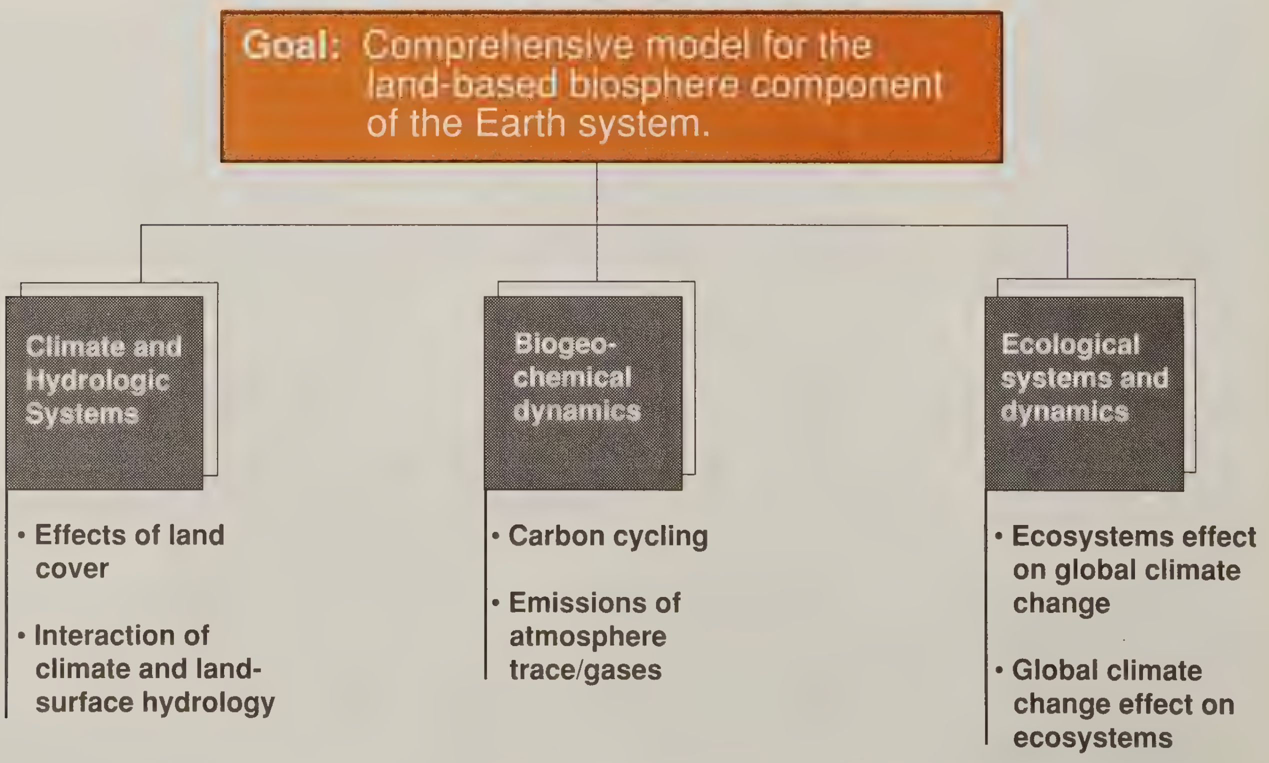
General Goal. Develop a comprehensive model for the land-based biosphere component of the Earth system as a means of understanding how both natural and human-induced processes will affect future environmental changes, as well as to provide the basis for designing response strategies that secure the continued productivity and health of the human life-support system.

This special research is part of USDA's contribution to the United States Global Change Research Program (USGCRP) coordinated by the Global Change Working Group of the Federal Coordinating Council for Science, Engineering, and Technology's Committee on Earth and Environmental Sciences. The main program goal is to develop a model of the Earth as an integrated system comprising land, ocean, and atmosphere. Preliminary models have been developed for the ocean and the atmosphere but not for land.

Most of the Earth's carbon-based products (food, fiber, fuel, and carbon-based chemicals) and our fresh water supply come from the Earth's thin, living skin, the terrestrial ecosystem. The U.S. land surface is covered primarily by crops, range, and forests—areas for which USDA has primary responsibility to develop the knowledge required to manage them and meet domestic needs.

The ARS program is divided into three major areas supporting high-priority science elements of the USGCRP: (1) climate and hydrologic systems, (2) biogeochemical dynamics, and (3) ecological systems and dynamics (fig. 3.2).

Figure 3.2. Global Climate Change Research Program



Climate and Hydrologic Systems. Major questions addressed by this research relate to how the exchange of water and energy between the land surface and the atmosphere will be affected by changes in land cover—including soil, vegetation, and snow—and how climate and land-surface hydrology will interact. Answers to these questions will affect policy responses to a wide range of environmental and economic issues including:

- Atmospheric warming. How temperature, precipitation, soil moisture, and severe weather patterns will be affected in the future by atmospheric warming caused by increasing concentrations of greenhouse gases.

- Water supplies. How information on the rate and degree of climate change will contribute to our understanding of the future availability of adequate water supplies.

- Food security. How our understanding of future water supplies, soil moisture, and climate will help us anticipate such events as drought, with serious impact on crop yields and world grain supplies.

Biogeochemical Dynamics. Major questions addressed by this research relate to cycling of carbon and other key elements between the atmosphere and the terrestrial biosphere. Answers to these questions will help address such policy issues as:

- Atmospheric warming. Predicted to be caused by increasing emissions of atmospheric trace gases (such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons).

- Stratospheric ozone depletion. Known to be caused by increasing emissions of halocarbons and other trace gases (such as nitrous oxide, methane, and carbon dioxide).

- Deforestation, irrigation, and other changes in land-use practice. Predicted to affect atmospheric concentrations of radioactively and chemically active trace gases and nutrient balances in terrestrial systems.

Ecological Systems and Dynamics. Major questions exist about the dynamic interactions among the physical and biogeochemical parts of the global system. One of our goals is to develop models that integrate the basic principles of dynamic ecosystems. These models will then help to develop and support policy decisions. The basic principles involve both causes and effects.

- How do ecosystems affect global climate change? How do ecological processes alter plant water balance, affecting local-to-regional hydrologic balance and the climate system? How do these processes change vegetation distribution that affects land-surface reflectivity, nutrient cycling, and sources and sinks of greenhouse gases?

- How are ecosystems affected by global change? How do changes in climate, atmospheric carbon dioxide concentration, ultraviolet-B radiation, and chemical deposition affect the health and distribution of ecosystems? How do land-use changes such as deforestation alter ecosystem dynamics?

ARS Utilization Research Program

General Goal. Strengthen U.S. global competitiveness through conversion of agricultural commodities to value-added food and nonfood products for export and domestic markets.

Traditionally, U.S. agricultural exports have been mainly low-margin, raw bulk commodities. These are increasingly available from several countries, thus giving rise to mounting competitive pressures. So the United States needs to create technology leading to an expanded, diverse range of value-added food and nonfood products from bulk commodities, plant-or animal-derived carbohydrates, lipids, and proteins.

In devising a strategy for creating food and nonfood product technologies, ARS program choice is motivated by various market demands: for safe, environmentally benign products and processes, for niche market specialty product technology to encourage creation of new U.S. companies, for diminished use of petroleum, for reduced imports of strategic materials, and for products tailored toward export market opportunities.

The ARS plan is to develop a balanced program for commodity conversion based on product value. In program decisionmaking, ARS will consider current and projected disciplinary capability, market niche, and projections about time needed to achieve success. The strategy will also consider program balance to obtain a continuous stream of research at the technology transfer stage over the long term.

The nonfood product types targeted for research to provide means of conversion are:

High Value Added. These products will generally target biomedical and veterinary markets currently supplied by the pharmaceutical industry. Advancing biotechnology methods, particularly in animal cell and tissue culture, should facilitate developing such products.

Substantial Value Added. Examples of products to be emphasized in this area would be:

- Environmentally compatible pesticides such as biopesticides by conversion of carbohydrates through fermentation.
- Biodegradable plastics or edible films such as food-encapsulating materials from conversion of starches or proteins.
- Miscellaneous biomaterials such as biodegradable surfactants, dispersants, chelating agents, antifoams, thickeners, and fillers for plastic foams.
- Industrial enzymes.
- Food additives such as natural flavors, colors, preservatives, and textural agents via fermentation or plant cell culture. These would have to have acceptable health-risks.

Moderate Value Added. Bulk chemicals and intermediates to include:

- Currently imported materials of strategic significance such as latex, vegetable gums, coconut and palm oils, and castor oil.
- Fermentation products with potential for becoming competitive with petroleum-based products such as ethanol, acetate, glycerol, or adipate.

Targeted percentages of nonfood product research in the projected programs are high value 20 percent, substantial value 45 percent, and moderate value 35 percent. The prime program emphasis is on substantial value-added products. This emphasis reflects the fact that these products would use significantly greater amounts of agricultural commodities than high-value-added products in their manufacture. Moderate value-added products would potentially convert more raw materials than the other two types. But because these products are subject to immediate economic challenge by foreign competition and petrochemical economics, their development will need to be spread over a longer term. An additional factor in program balance factored with product unit value is projected total market value of the targeted product.

Crosscutting Programs

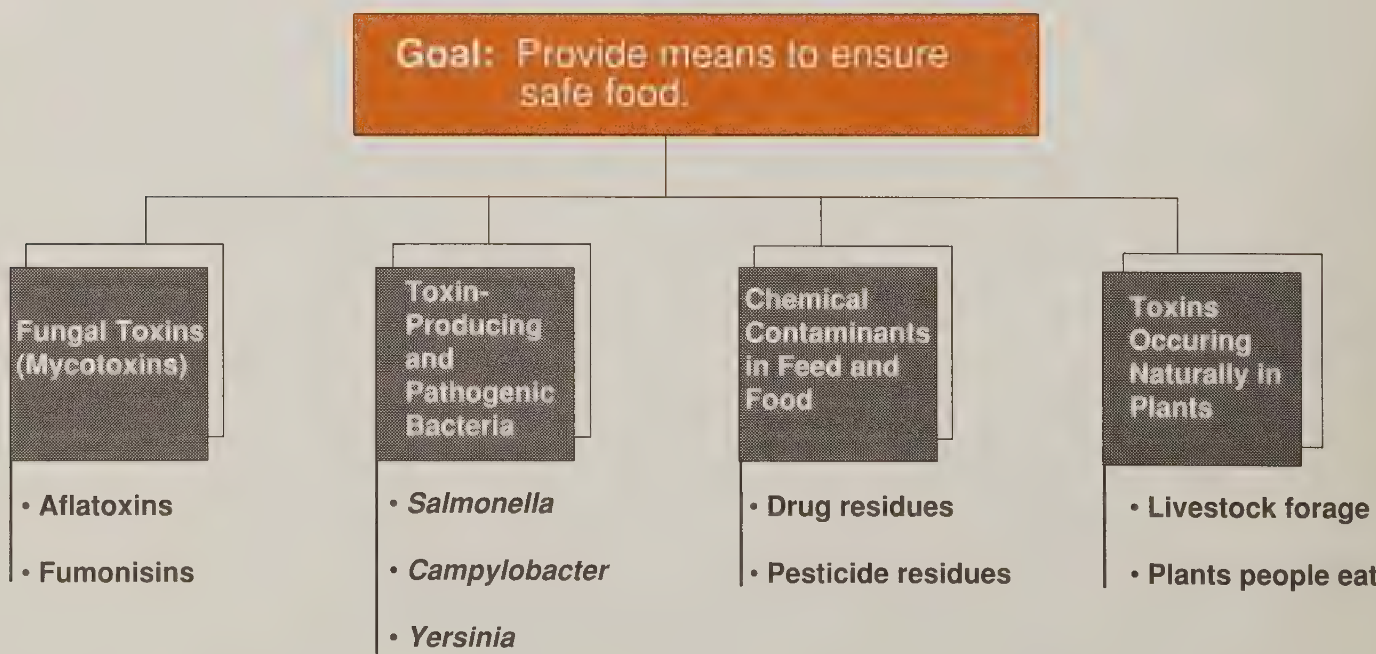
Many of ARS' national research programs are composed of several smaller national programs and research projects that do not fall under one ARS Program Plan objective. ARS' ability to focus several smaller programs on broad national problems is one of the agency's great strengths. Several examples of such programs are highlighted below; these have been designated as high priority by ARS, USDA advisory bodies, the Department, and Congress. They are food safety, human nutrition and health, water quality, and environmentally compatible pest control.

Food Safety

General Goal. Provide means to ensure that the food supply is safe for consumers and that food and feed meet foreign and domestic regulatory requirements.

A major research direction in the food safety program (objective 4) is to decrease the potential hazards of introduced toxicants in food and feed. These include: mycotoxins, toxin-producing and pathogenic bacteria, feed and food chemical contaminants, and toxins occurring naturally in plants (fig. 3.3).

Figure 3.3. Food Safety



Fungal Toxins (Mycotoxins)

These toxins are generated after a fungus invades plant and seed tissues under specific field and storage conditions, unique to each toxin producer. The national program goal is to eliminate two major toxin groups (aflatoxins and fumonisins) from the food supply. This research seeks to prevent toxin formation by exploiting the weak links in toxin generation in ways that have the lowest potential for disrupting the ecosystem. Genetic manipulation for host-plant resistance, alternative production management practices, and biocontrol of insect vectors (objective 2) together with the identification of nontoxin-producing competitive fungi (objective 4) are important parts of this program.

Toxin-Producing and Pathogenic Bacteria

General scientific agreement exists that toxin-producing and pathogenic microorganisms offer a greater hazard than chemical residues in the food supply. ARS has designated food and feed contamination by toxin-producing and pathogenic microorganisms a high-priority research program for the 1990's and a major area of ARS research meeting the needs of USDA's Food Safety and Inspection Service. Targeted microbes include *Salmonella*, *Campylobacter*, and *Yersinia*. Effective control will depend on design of management procedures for production of pathogen-free meat, milk, and eggs (objective 3). The research will also emphasize new approaches to methods of detection, alternative processing, and definition of micro-environmental conditions in food that are conducive or unfavorable to pathogen growth (objective 4).

Feed and Food Chemical Contaminants

Elimination of chemical contaminants—primarily drug residues—from human food is a major national research program responding to needs of USDA's action and regulatory agencies (objectives 3 and 4). Development of strategies for reduction of harmful pesticides (objective 2) and control of plant uptake of toxic heavy metals such as cadmium and selenium from ground or runoff water in crop production (objective 1) are other high-priority research areas.

Toxins Occurring Naturally in Plants

Decreasing the potential hazards introduced from toxins occurring naturally in plants is another goal. Those that occur in plant materials consumed by livestock can directly cause stock losses or present a secondary hazard to humans through residues in meat, milk, or eggs. The major programs to control these toxins are identification of significant toxins in the major plants causing livestock losses, characterization of their chemical nature, quantification during various phases of plant growth to identify safe intake period, development of management and control practices specific to each plant, and processing technologies for eliminating the toxins. This research crosscuts objectives 3 and 4.

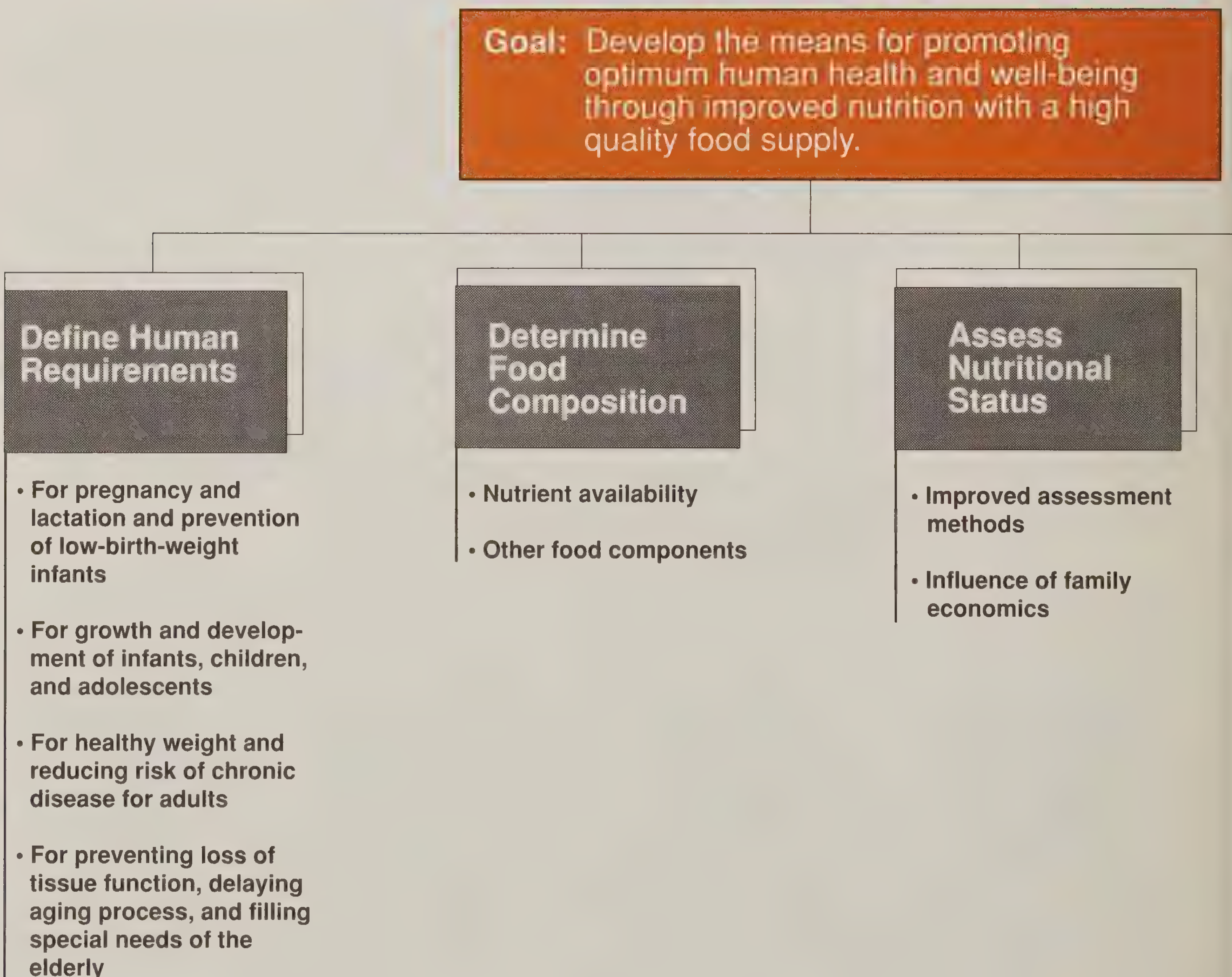
Plants eaten directly by humans also carry naturally occurring toxicants, potentially more hazardous than introduced contaminants. A program goal is to reduce or eliminate significant naturally occurring toxicants through direct manipulation of the plant genome to prevent expression of key enzymes in biosynthetic pathways (objective 2).

Improved Human Nutrition and Health

General Goal. Develop the means for promoting optimum human health and well-being through improved nutrition with a high-quality food supply.

Research programs (fig. 3.4) through which this goal is to be achieved include elements in objectives 2, 3, 5, and 6.

Figure 3.4. Improved Human Nutrition and Health



Improve Nutritional Quality of Foods

- **Reduced fat in animal products**
- **Improved quality of nutrients and other health-promoting components in plants**

Human Nutritional Requirements

The goal is to define the requirements and safe limits of energy and nutrient intakes of humans throughout the life cycle.

- Needs of infants and of pregnant and lactating women. Emphasis is placed on defining the energy, protein, amino acid, calcium, zinc, and iron needs of infants and lactating women, using nonradioactive stable isotopes as metabolic tracers. Projected extension would include requirements for the growth spurt of adolescents and during teenage pregnancy. The role of lactoferrin from human milk on the early development of the gastrointestinal tract will be further defined. Food utilization studies will involve mainly cereal foods.

- Requirements for the elderly. Studies are directed toward how diet and exercise affect physical strength and performance; how dietary vitamin D, calcium, and boron affect maintenance of bone density and prevention of osteoporosis and bone fractures; how atrophic gastritis affects utilization of dietary folacin and vitamin B12; how cataracts are related to vitamin C and other antioxidant nutrients; and how high levels of vitamin E affect immune response. Studies are also underway on vitamin K, vitamin B6, and protein requirements of the elderly.

- Reduction of obesity and chronic disease risk. Studies will be designed to determine the effects of different dietary levels of specific fatty acids and fats, the role and function of dietary fiber components, and the effect of trace elements and nutrient interactions on risk of diet-related chronic diseases. Research will define the factors that influence energy intake and expenditures in individuals.

Food Composition

Aim is to determine the composition of agricultural commodities and foods as eaten and establish the bioavailability of their nutrients and other constituents important to health.

- Nutrients. A major emphasis is on development of sampling, analyses, and quality control methods needed to acquire representative food composition data on nutrients in foods that contribute importantly to U.S. diets. Focus is on fatty acids, carotenoids, dietary fiber components, and trace elements in chemical forms found in foods and their respective availability (objective 4).

- Other phytogenic constituents. Emphasis is on measurement of levels of compounds formed as constituents of foods and associated with reduced chronic disease rate, especially colo-rectal cancer and cardiovascular disease.

Targeted compounds include carotenoids of green and yellow vegetables, phenols of cole crops, and bioflavonoids of citrus. Suitable methods of analysis and generation of food composition databases (objective 4) are needed to help improve plant varieties (objective 2).

Improved Methods of Assessing Nutritional Status

Efforts will be directed at developing rapid, reliable, and cost-effective methods of identifying marginal nutritional status; these methods need to be suitable for use under field conditions and are required for assessing effectiveness of feeding and education programs and for nutrition monitoring.

Integrate Knowledge Into the Food System

Strategies will be devised for food production systems that will enhance nutrition.

- Improve nutritional quality of animal products. Emphasis on new research approaches to devise ways to modify types and amounts of fat and fatty acid composition, while retaining quality of meat and milk products. Biotechnological approaches to improve existing germplasm will be pursued to produce more desirable products (objective 3).

- Designing nutritionally improved plant foods. Means will be pursued to improve trace mineral content in cereal products and to reduce levels of antinutrient constituents that interfere with nutrient availability (objective 2). Effort will focus on improvement of plant foods with regard to their dietary fiber components and other phytogenic constituents (anticarcinogens, etc.) of health significance. Specific research will be directed toward increasing the amylose starch component in foods to improve nutritional quality.

Water Quality Protection

General Goal. Assess what effect agriculture has on water quality and develop new agricultural management practices and systems that are cost effective and will protect and enhance water quality.

Widespread public concern exists over agricultural activities that may contribute to degradation of ground and surface waters. Potential contaminants from agricultural sources include pesticides, nutrients, sediments, salts, toxic trace elements, livestock and processing wastes, and other organic and natural toxicants. Pursuant to the 1990 President's Initiative on Enhancing Water Quality, ARS has substantially strengthened its research and development program and expanded the work to include many scientific disciplines. In implementing its program, ARS is working with other USDA agencies, other Federal agencies, and State cooperators through the USDA Working Group on Water Quality.

Major research areas are proposed to:

- Provide new crop and livestock management practices and systems to reduce the chances of water quality degradation under a wide range of conditions while maintaining economic viability.

- Develop new knowledge of the mechanisms and factors that govern the fate and transport of agricultural chemicals and other potentially hazardous materials within soils and geologic materials.

- Develop new technologies and optimal experimental strategies for evaluating the economic and environmental consequences of current and alternative farming systems.

- Analyze broad social and economic effects of current and new management methods to compare relative overall cost effectiveness of alternative practices and systems.

Research programs to achieve these goals include elements of objectives 1, 2, 3, and 6.

Assessment of Agriculture's Impact

Research will be conducted to develop and improve laboratory and field methods for rapidly, reliably, and cost-effectively sampling and analyzing pesticide residues and other potential contaminants and for determining the rates at which water and chemicals move through soil to ground water. Initially, research will give priority to developing improved sampling and analytical methods. Improved sampling methods will provide the means to obtain accurate and representative data at reduced cost, including sampling strategies and protocols that accurately determine variability over space and time.

Understanding the fundamental processes affecting fate and transport of potential agricultural contaminants will provide the basis for development of decision aids and models to evaluate current farming practices and develop new practices and systems. Key aspects of water and chemical transport will be characterized to include the physical, chemical, and biological processes involved in nitrogen transformation, pesticide degradation, and the factors affecting sorption and storage of other inorganic and organic materials in the soil (objective 1).

A major focus will be on development of procedures needed by action and regulatory agencies to determine the current potential for water contamination. Goals are to define effects of pesticide and nitrogen management, tillage and crop management, irrigation and drainage management, and livestock management (objectives 1, 2, and 3).

Current agricultural practices will be evaluated in large-scale Management Systems Evaluation Areas (MSEA) to determine the severity and extent of agricultural contamination in specific geographic areas. This is a joint effort of ARS, USDA's Cooperative State Research Service, State agricultural experiment stations, the U.S. Geological Survey (USGS), and the Environmental Protection Agency (EPA). MSEA sites will concentrate on corn and soybean production areas in the Midwest (objective 1). Portions of the USGS's Midcontinent Herbicide Initiative along with the EPA's Midwest Agrichemical Surface/Subsurface Transport and Effects Research Program will also be incorporated into the MSEA program. Consideration will be given to instrumenting additional MSEA locations outside the Midwest, when assessment technologies now under development delineate areas with the potential for significant water quality degradation by agricultural chemicals.

Development of New Agricultural Practices and Systems

New agricultural practices and systems will be developed to protect, improve, or remedy water-quality problems. Soil, water, crop pest control, livestock, and other best-management practices will be integrated into a systems approach that reduces negative agricultural effects (objective 6). New methods of chemical storage and handling, chemical application, and disposal of chemical containers will be used to reduce accidental chemical spills and rates of chemical usage (objectives 1 and 2). A set of diagnostic tools—such as soil tests, plant tests, biosensors, and tracers—will be developed to improve chemical pesticide application methods (objectives 1 and 2). New knowledge and management strategies for disposal of animal wastes on crop and rangelands will be developed for water quality protection.

Biological control research will introduce bioherbicides, biofungicides, bionematicides, and biological methods for insect and weed control (objective 2). Plant breeding and germplasm research will stress means to achieve more efficient utilization of nitrogen by major crops. Genetic manipulation of plants will also focus on plant resistance to insects and diseases that require use of pesticides most likely to threaten water quality (objective 2).

Figure 3.5. Ground and Surface Water Quality Protection Program

Systems Integration and Evaluation

Water-quality decision aids and models will be modified and developed to include risk management technologies for the evaluation and comparison of systems for reducing contamination. Decision aids will include economic, social, and environmental effects and will be made available to education and technical assistance agencies, farm consultants, and other Federal and State agencies.

New agricultural practices and systems will also be developed to reduce effects on other ecosystems, with major concern for effects on fish and wildlife habitats. The effects of agricultural drainage on freshwater lakes, streams, and adjoining habitats will be considered in terms of use and protection of public lands (objective 1).

Regional information systems will be developed that can be used to design and implement agricultural management systems to minimize contamination by pesticides and nutrients. Geographic information systems will be used to compile and store water-quality data on best-management practices, and the systems will be expanded to include priority areas where environmental variables and factors are unknown. Priority components of management systems will be prioritized and categorized into groups relating their risk with soil, climatic, and landscape properties for selection by farmers and ranchers (objectives 1, 2, 3, and 6).

Decision support systems will be developed to assist farmers, ranchers, and land managers in selecting best management practices to produce food and fiber without wasting expensive chemicals or having them become pollutants. This will allow comparisons with alternatives and document the decision process (objective 6). The overall ARS water-quality protection program is shown in figure 3.5.

Environmentally Compatible Pest Control

General Goal. To manage pests by developing safe and environmentally sound alternatives to reduce reliance on classical chemical pesticides and, at the same time, ensure a safe, high-quality stable supply of food and fiber.

National programs for achieving this goal include research under objectives 1, 2, 3, 4, and 6 of the ARS Program Plan.

The main research emphases of this program are on development of environmentally responsible pest management systems designed to use all suitable methods to keep pest populations below levels that result in economic damage to a crop. Five major technical areas that address pest control approaches, especially IPM (integrated pest management), will be integrated into appropriate production systems.

- Host resistance to pests in the crop plant is a major technical objective. Host resistance is the most durable and one of the most effective means to protect crop plants and their economic parts not only during production, but also perhaps during processing and distribution. Introduction of new or ancestral host resistance factors and augmentation of existing natural resistance will be pursued.

- New and improved biological agents for controlling plant pests remain important components of the integrated program. Particular emphasis will be given to overcoming technical barriers associated with use of biological agents against plant pathogens and diseases. These include unraveling the complexities of microbial communities in selected plant ecosystems that inhibit control organisms and developing means to measure and establish a favorable balance between beneficial and harmful microorganisms.

- Biologically based alternatives to be emphasized for control of major insect and weed pests include naturally occurring chemicals that modify behavior (that is, semiochemicals, which include pheromones), life cycle disruption, natural plant protectants, and release of sterile insects. Use of biotechnological means to enhance desirable biological interactions or to disrupt undesirable interactions at the molecular level will be emphasized for both disease and insect pest control systems.

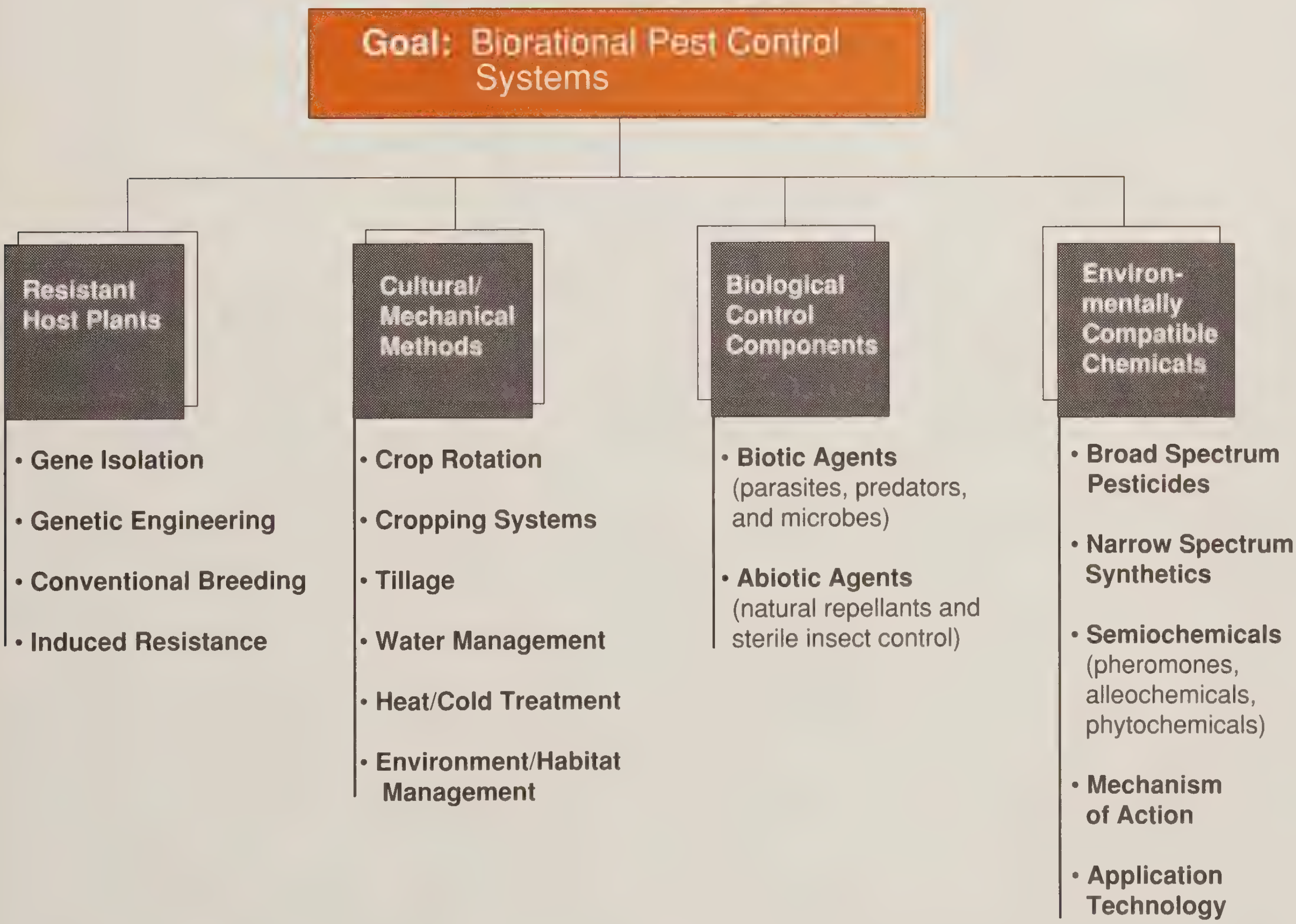
- Means to reduce potential environmental effects of pesticide chemicals. Prudent and judicious use of chemical pesticides is likely to continue for some time before suitable alternatives are developed, to protect crop production capacity. Means must be sought to improve chemical application technology (objectives 1 and 2) and the selectivity of chemical agents. Such technologies can limit adverse effects on nontarget and beneficial organisms. They can also reduce levels and frequency of application and therefore minimize unacceptable residues in the environment and food supply (objective 4).

- Cultural practices designed to avoid infection by plant pathogens and infestation by insects. These practices will complement genetic resistance of crop plants. Such practices include crop rotation, cultivation, pruning, fertilization, pH control, sanitation, planting/harvest timing, and postharvest practices. Cultural systems designed for integration with biocontrol systems will be specifically targeted, as will those designed to reduce undesirable environmental and human health effects.

Development of systems integration data, protocols, and computer models will be emphasized as being as integral to systems development as they are appropriate to individual cropping systems under study (objectives 4 and 6).

The overall ARS program to achieve environmentally compatible pest control is shown in figure 3.6.

Figure 3.6. ARS Research Program To Provide Environmentally Sound Pest Control Systems



6

Section IV—Implementation Strategy—1992-1998

ARS has established, and documented in the ARS Program Plan,[1] policies that describe roles and responsibilities for the following six key activities related to planning, managing, and conducting ARS research:

- National planning and coordination
- Determination of program content
- Establishment of priorities
- Program implementation and management
- Review and evaluation
- International activities

These policy statements, discussed fully in an updated form in appendix E, continue to provide a stable foundation for the principles and standards by which ARS program objectives will be achieved.

In earlier versions of the 6-year implementation plan,[2,3] ARS also adopted seven implementation strategies related to operational policies for planning and conducting research. These seven strategies (see "Progress Toward Fulfilling Implementation Strategies," p. 8) continue to be relevant to the 1992-1998 planning period.

Using these policy statements and implementation strategies as a foundation, ARS has adopted additional implementation strategies to guide research planning and resource management from 1992 to 1998. These new strategies, outlined below, have been developed through careful analysis and evaluation of ARS' operating and funding experience from 1982 to 1991.

1. ARS will continue to carry out that research—fundamental and applied—necessary to solve specific, identified problems.

- ARS research planning will be based on problem identification; specification of goals, objectives, and expected outcomes; and identification of gaps in knowledge that impede solution of specific problems. To integrate these factors, ARS will use systems-based decision methods such as decision trees and critical path analysis.

- To ensure maximum effectiveness of the process used to obtain contributions to the planning effort from policy officials, scientists, cooperators, farmers, agribusiness, and consumers, ARS will continue to use and improve its total quality management (TQM) approach.

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[1] Agricultural Research Service Program Plan. U.S. Department of Agriculture, Agricultural Research Service, Miscellaneous Publication 1429. 1983. (Out of print.)
[2] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1984-1990. U.S. Department of Agriculture, Agricultural Research Service. 1983. (Out of print.)
[3] Agricultural Research Service Program Plan. 6-Year Implementation Plan, 1986-1992. U.S. Department of Agriculture, Agricultural Research Service. 1985. (Out of print.)

- The ARS research program currently has an approximately 50:50 ratio of fundamental-to-applied research in its overall program structure. The program projections for 1992 to 1998 do not indicate any significant change in this ratio. ARS deems this ratio productive for a mission-oriented agency because even its fundamental research is targeted to solving problems and filling specific gaps in knowledge. Also, in the ARS system, fundamental and applied research are interrelated; the applied research depends on the knowledge gained in the fundamental research. To achieve greatest efficiency in solving problems, ARS research planning rarely relies on a given scientist to carry out the full spectrum of research from initial stages to complete solution—or developed product or process. Instead, the agency can deploy an array of scientists working on several aspects of a problem at the same time.

2. ARS base programs—whether identified as long-term, high-risk research or responding to immediate needs of the Department or Congress, ARS clientele, and USDA action/regulatory agencies—must be based solidly on sustained funding from congressional appropriations.

3. ARS will aggressively seek annual budget increases to address priority research needs and to strengthen important base programs.

- Clientele, Department, and congressional demand for ARS research has increased.

- There is increased expectation from industry for the Federal research sector to carry out fundamental and other pre-market research. Industrial fiscal pressures and increased need for research to protect existing markets are limiting industrial capability to support pre-market research.

- ARS will aggressively plan new research initiatives and augmentation of priority research programs to meet user needs within the boundaries of USDA and other administration policies and allowances.

4. ARS will seek outside funding support (such as grants and funds received from other Federal agencies) to supplement or accelerate base-funded, in-house programs.

- Such funds will be sought from industry, from competitive grant sources, and as passthroughs from other Federal agencies and must conform to the following criteria:

  - Their use is consistent with base-funded project objectives and the accountability requirements of the Department, Congress, and research users.

  - Funds from other Federal agencies are acceptable to ARS when the research carried out is relevant to and consistent with ARS' mission and will help carry out the mission of the funding agency and when ARS has the appropriate scientific capability.

- There is no established limit or proportion of outside funding relative to base funding that can be set by policy. Such a balance is best determined case by case, based on actual project needs and other onsite circumstances. But pursuit of outside funding must not interfere with use of base funds to carry out the ARS mission.

5. ARS will not depend on new or outside funds alone to support priority research but will manage and effectively deploy its existing base resources.

- Although ARS has received modest annual budget increases averaging 3 to 5 percent over the last 10 years, overall these increases have not kept pace with inflation and the increased costs of performing quality research (see "Funding Status 1991," p. 5). Also, most of the increases have been used to augment or initiate specific areas of research emphasis.

- Management of the base program is a primary concern since the $624 million ARS base program allocation is vastly larger than any annual budget increase anticipated. Furthermore, ARS assumes that base program funds will be larger than any aggregate increases likely to be accumulated over the entire planning period.

- Within the bounds of mission, location, program area, and accountability to commodity and user group needs, ARS will use as much discretion as possible to redeploy resources to support the most important and promising research objectives and approaches.

6. ARS will strive to establish and maintain peer-reviewed research projects at adequately funded levels adjusted for inflation. Current planning levels for 1992 are $250,000 per year for each career scientist. Not all projects will require this level of support. Assessment of adequate funding levels for individual projects will depend on the nature of the research and its related costs.

- This planning funding level covers the full complement of research costs such as scientist salaries, support personnel and technicians, postdoctorals, temporary or seasonal personnel needs, equipment and instruments, travel, collaborative research, and indirect (operational) research costs.

- To the extent that annual budgets do not meet priority needs and the ability to maintain projects at well-funded levels, ARS will redeploy existing resources and redirect research from lower to higher priority needs as required.

- Criteria for project redirections or resource redeployment are:

  - Priority ranking. This is a judgmental, but systematic process. Ranking of ARS research reflects the agency's internal assessment of the priorities of the Department, USDA action agencies, other Federal agencies, the Congress, commodity and industry groups and organizations, consumers, professional societies, ARS and university scientists, USDA advisory bodies, consumers, and other clientele.

  - Resource adequacy or availability. Project or program assessment often reveals that allocated resources (fiscal, physical, scientific) are inadequate to achieve the research objectives. Such findings may, for example, indicate that the resources would be more efficiently used to bolster or even initiate another program area.

  - Fit to mission (agency location) at national program level. This entails assessing relevance of specific projects to the broad goals and objectives of the national research program.

- Probability of technical success. This criterion applies to proposed research as well as to research that has had adequate time to reach a technical decision point. That decision will be based on assessing whether initiating or continuing a project would be the best use of available resources.

- Research at a point where the technology can be transferred. This criterion responds to the question "Has ARS taken this line of research as far as it should in terms of ARS mission and responsibility?" There is no established point in the research and development continuum at which ARS effort or a particular project should cut off. In research for which technology transfer is targeted to industries that have strong R&D capabilities, the cutoff point would probably be considerably sooner than research for which users are entrepreneurs or practitioners (such as farmers or ranchers) with little R&D capability of their own.

7. ARS will develop a methodology for the implementation of a workforce planning system designed to respond to the scientific and other personnel needs of projected program areas of emphasis. Effective management of ARS human resources will include an improved system to reward significant employee contributions to the agency's mission, goals, and objectives.

- ARS will continue to work toward accomplishing EEO hiring objectives designed to achieve workforce diversity. Inherent to the achievement of workforce diversity is the need to educate and train the existing workforce on adapting to labor force changes predicted for the turn of the century.

  - ARS has developed working relationships with the 1890 land-grant institutions and the Hispanic Association of Colleges and Universities (HACU) member institutions. These relationships will contribute significantly to accomplishing mission-related goals as well as to realizing outreach efforts to achieve a diversified workforce.

  - As part of the planning to meet future workforce needs, ARS will continue both formal and informal outreach initiatives to influence and strengthen science curriculums; interest elementary, junior high, and high school students in scientific and technical careers; expand student employment programs; and encourage faculty exchange programs.

ARS will continue to adapt its Research Performance Evaluation System (RPES) to give scientists full credit for contribution to the ARS mission, goals, objectives, and policy implementation.

- ARS has long and successfully used internal scientific peer review to establish scientists' grade/pay classification status. This system has traditionally and primarily been based on an assessment of the quality and impact of a scientist's personal research accomplishments in performance of assigned research.

- ARS has adopted procedures and policies for peers to recognize and give credit to scientists' supplemental contributions toward program goals. Supplemental contributions involve research leadership, project management, project coordination, special assignments, support of action agencies, team research, and technol-

ogy transfer in addition to the basic criterion of personal research accomplishments. ARS will also give increased attention to recognizing a scientist's efforts in acquiring training for leadership development and providing training for others. Peer-reviewed technical publications will not be the exclusive measure of progress and contribution.

8. ARS will systematically upgrade and modernize its facilities on a priority basis and seek additional funding through the budget process to augment its limited base resources for this purpose.

- Department, congressional, and user expectations of ARS can be fulfilled only if the ARS physical plant provides a research environment attuned to the developing needs of scientific research over the next 50 years.

- The replacement value of the ARS physical plant is $1.7 billion.

- ARS will systematically evaluate programs to establish priorities for upgrading and modernizing facilities.

- ARS began implementing a renovation and modernization plan in 1982, but its capability to accomplish planned renovation and modernization within the restrictions of its base funds has proven inadequate.[1]

- ARS will give equal priority in the budget development process to facility improvement and to program enhancement.

9. ARS will further improve processes, operational methodology, and integrated systems for long-range strategic planning via multiyear operational planning by line (area) management.

- ARS implementation policies (policies 1 and 4, appendix E) make area management responsible for developing and updating their operational plans in accordance with periodic adjustments to the 6-year implementation plan. Multiyear area operational plans will become part of ARS' comprehensive planning system.

- To date, three elements in the ARS planning system are operative: (1) the program plan used as a research program framework, (2) the 6-year implementation plan—a midrange instrument that provides research program priorities and operating policy for two complete budget cycles, and (3) the ARS resource management plans (ARMP) in which area management details 1 year's operational planning.

- Multiyear plans are needed for adjustment of field operations to priorities and strategies of the implementation plan, budgetary decisions, changing national research priorities, and facilities modernization needs. These implementation actions do not fit 1-year action plans (ARMP). A 3-year field operating plan process and format will be developed to fill these needs.

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[1] Agricultural Research Service, Modernization Needs Over $1 Million, 1990. Prepared by Office of the Deputy Administrator for Administrative Management, Facilities Construction Management Division.

10. ARS will improve its technology transfer support functions as needed to achieve planned agency goals and objectives.

- As a Federal research agency, ARS recognizes that its responsibility does not end with conducting and publishing research. Getting the results of that research expeditiously adopted and used to achieve the agency's goals is also essential. Accordingly, ARS will continue to enhance its efforts to transfer new knowledge and technology to users and further developers of the research. A key component of these efforts is close cooperation and interaction with those users and developers—such as action and regulatory agencies, Federal and State extension organizations, and industry. Such cooperation not only facilitates technology transfer, but also provides critically important feedback for research planning.

- ARS will continue to aggressively implement the Federal Technology Transfer Act of 1986 and related laws, regulations, and Executive Orders. Collectively, these establish today's tools for transferring technology to industry: CRADA's (cooperative research and development agreements), government/industry/university consortiums, and new legal authority regarding patent licenses. Using these tools, ARS will work toward a goal of doubling the rate of commercialization of new technology from ARS research by 1998.

- ARS will update and upgrade its software base to better implement coordination and integration of staff and line functions (policy 1, appendix E). As ARS programs evolve towards larger, more interdisciplinary and cross-cutting programs, major assistance from computer databases and management information systems will be required. Such systems must provide both research leaders and researchers means to operate with the same database, thus linking systems capable of handling both data entry and data retrieval by sources and users.

- ARS will continue to maintain an active information and education program to report research progress to the public to aid technology transfer as well as provide usable knowledge to a broad spectrum of interested parties.

Appendix A—ARS and Area Organizations

Agricultural Research Service — Area Organization

○ **Area Headquarters**

◉ **Research Centers**
ERRC, Philadelphia, PA
NCAUR, Peoria, IL
SRRC, New Orleans, LA
WRRC, Albany, CA
BARC, Beltsville, MD
NADC, Ames, IA
PIADC, Plum Island, NY

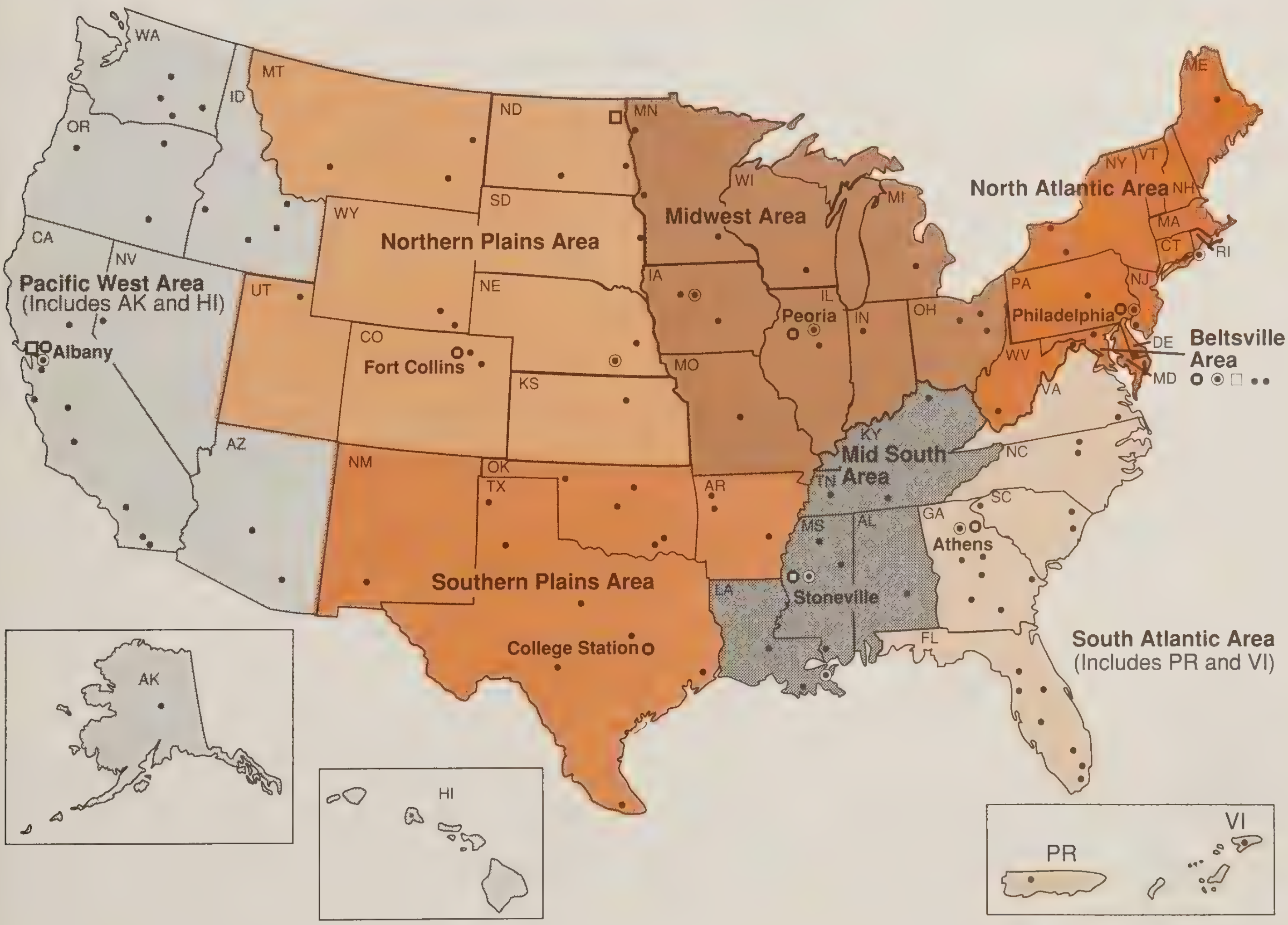
Richard B. Russell Research Center, Athens, GA

Roman L Hruska U.S. Meat Animal Research Center, Clay Center, NE

Jamie Whitten Delta States Research Center, Stoneville, MS

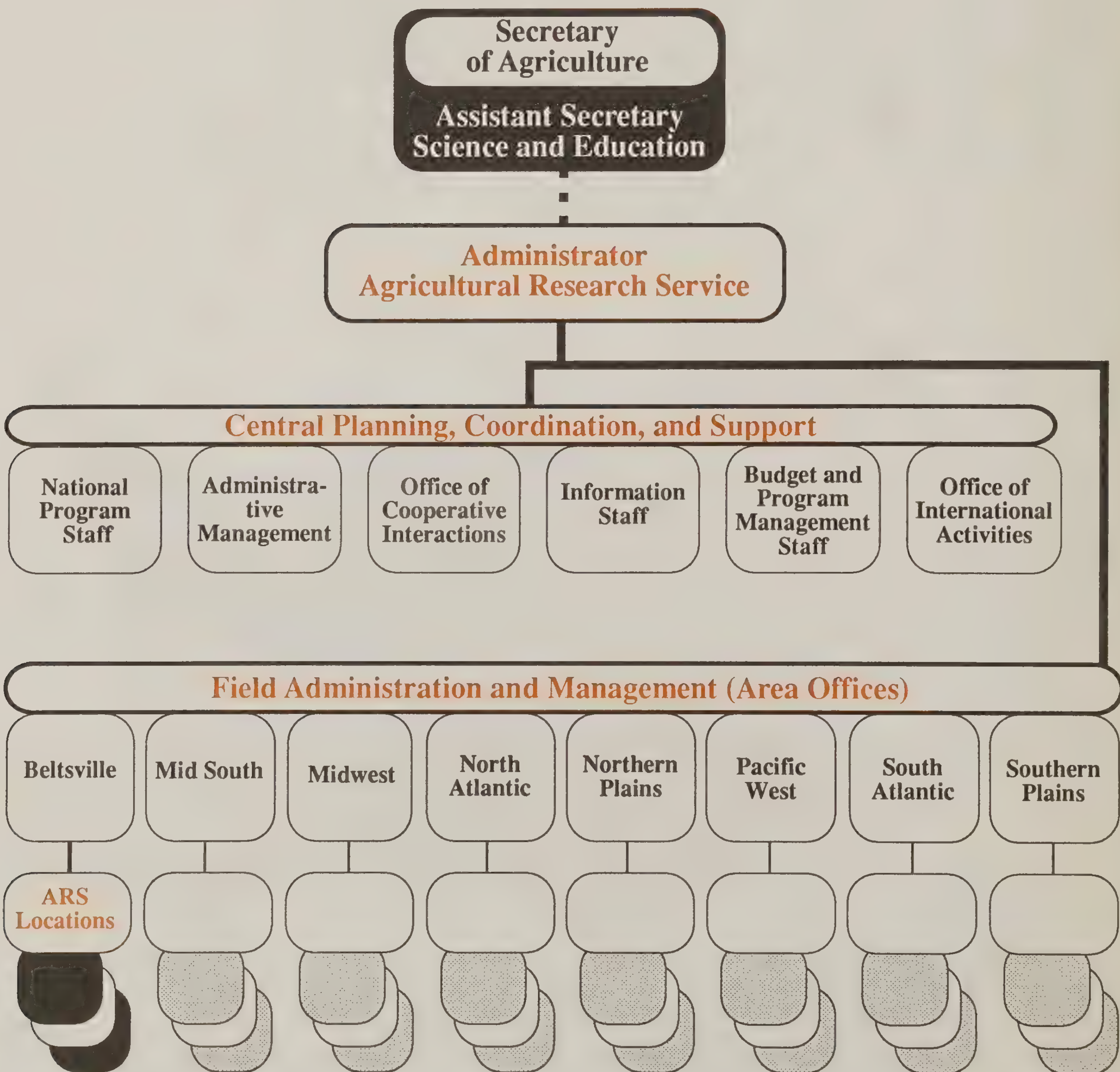
□ **Human Nutrition Research Centers**
Beltsville, MD
Boston, MA
Grand Forks, ND
Houston, TX
San Francisco, CA

● **Research Locations**



October 1991

Agricultural Research Service—Organization



Appendix B—ARS Program Plan Objectives, Approaches, and Approach Elements, Revised 1991

1—Soil, Water, and Air

Enhance and improve management of the Nation's soil, water, and air resources to optimize agricultural production and environmental quality.

1.1—Atmosphere and Climate

Understand the effects of atmospheric chemical composition and climate on basic resources and productivity and the effects of agricultural practices on processes that affect atmospheric chemical composition and climate.

1.1.1—Plant Response

Understand plant response and quantify the effects of increased concentrations of atmospheric chemical constituents and of temperature, water, radiation, and wind on processes affecting agricultural and ecosystem functions, productivity, water use efficiency, and plant community composition.

1.1.2—Soil-Plant Systems as Gas Sources/Sinks

Understand the processes that affect the evolution and absorption of gases in soil-plant systems that are significant to atmospheric chemistry and to radiation quantity and quality.

1.2—Soil

Develop technology needed to assess, protect, and improve soil resources; increase production efficiency of soil; improve absorption and efficiency of precipitation use; and enhance environmental quality.

1.2.1—Erosion

Develop technology to understand, assess, and control erosion from crop and range lands.

1.2.2—Plant Nutrient Management

Develop cost-effective crop sequences and soil/organic matter/fertilizer/weed control practices that will improve production efficiency and environmental quality.

1.2.3—Soil Management

Develop understanding, practices, and equipment to improve soil structure, aeration, and seed and fertilizer placement; to increase infiltration, rooting depth, and precipitation use efficiency; and to enhance environmental quality and productivity of crop and range lands.

1.2.4—Basic Soil Processes

Understand the effects of aeration, redox potentials, ultraviolet light, ozone, water content, mineralogy, and fertilizer/organic matter additions on transformations/mobility/uptake of plant nutrients, pesticides, and other soil components that can affect crop production and food/water quality.

1.3—Water

Develop technology to assess, protect, and improve water quality and quantity; increase water use efficiency; and enhance environmental quality.

1.3.1—Hydrology/Sediment Transport
Develop technology to assess, store, and manage water supplies and to reduce damage from drought, floods, stream erosion, and sedimentation.

1.3.2—Soil-Water-Plant Interactions
Develop technologies and practices to reduce plant water stress and ameliorate its effects, increase water-use efficiency, and conserve energy.

1.3.3—Irrigation and Drainage
Develop irrigation/drainage systems and practices to improve distribution, timing, amount, and uniformity in applying irrigation water and in combining irrigation-drainage systems for optimized crop production and environmental quality.

1.3.4—Assessing and Improving Water Quality
Assess levels of essential, beneficial, and environmentally compatible solute concentrations of ground and surface waters; develop new, improved, and cost-effective production systems that will ensure safety ranges for these concentrations.

2—Plant Productivity

Develop technology for increasing plant productivity and quality.

2.1—Plant Production

Improve the production efficiency of plants and quality of plant products.

2.1.1—Germplasm Collections and Biosystematics
Increase potential for germplasm utility through acquisition, characterization, documentation, and preservation activities, including related systematic, ecogeographical, and conservation research.

2.1.2—Plant Genetics and Breeding
Use evaluation, selection, molecular/cellular genetics, transformation, tissue culture, micropropagation, and breeding techniques to enhance plant germplasm and develop improved genetic material to improve production efficiency and product quality.

2.1.3—Biochemistry, Physiology, and Reproduction
Increase carbon/nitrogen/mineral utilization efficiency and partitioning and nutrient utilization; determine metabolic processes and their regulation to improve productivity and food/fiber product quality and to maintain product safety.

2.1.4—Equipment for Production and Harvesting
Develop equipment associated with crop production and harvesting for improved efficiency and product quality.

2.1.5—Insect Pollinators
Develop technology for improving insect pollination of major agricultural crops.

2.1.6—Crop Management
Develop new knowledge and methods for applying management principles associated with crop production or protection for a more efficient agriculture.

2.2—Plant Protection

Control pathogens, nematodes, insects, mites, and weeds to sustain or improve production efficiency in ways that will maintain or enhance natural resources and the environment.

2.2.1—Pathogens and Nematodes
Develop improved technology to prevent, reduce, or eliminate losses from pathogens and nematodes.

2.2.2—Insects and Mites
Develop improved technology to prevent, reduce, or eliminate losses from insects and mites.

2.2.3—Weeds
Develop improved technology to prevent, reduce, or eliminate losses from weeds.

2.2.4—Agrochemical Technology
Develop improved agricultural chemicals technology for effective, economic, and safe methods of pest control.

3—Animal Productivity

Develop technology for increasing the productivity of animals and the quality of animal products.

3.1—Production

Improve the production efficiency of animals and quality of animal products.

3.1.1—Germplasm
Develop knowledge and technology to support the establishment and maintenance of a nationally coordinated animal germplasm program.

3.1.2—Genetics
Increase the genetic production capacity of animals.

3.1.3—Reproduction
Improve efficiency of reproduction and related biological processes.

3.1.4—Nutrition
Improve animal nutrition and feed use to increase production efficiency.

3.1.5—Composition of Products
Improve the nutrient composition and quality of animal products.

3.2—Protection of Animal and Human Health

Prevent, reduce, or eliminate losses from diseases, pest organisms, and chemicals affecting animal performance, welfare, and product quality.

3.2.1—Diseases
Prevent, reduce, or eliminate losses from foreign and domestic diseases.

3.2.2—Parasites
Prevent, reduce, or eliminate animal losses from internal and external parasites.

3.2.3—Contamination
Prevent, reduce, or eliminate losses of animal products from biological and chemical contaminants that may affect human health.

3.2.4—Animal Well-Being
Enhance knowledge of animal needs in modern production facilities to improve and advance the well-being of farm animals.

4—Commodity Conversion and Delivery

Develop technology for enhancing the quality and use of agricultural materials to meet domestic and global market demands.

4.1—New Uses, New Products

Broaden markets for, create new markets or uses for, or otherwise improve the quality and utility of products derived from agricultural commodities.

4.1.1—Industrial Products (Nonfood)
Identify markets and develop technologies and process-engineering systems that lead to value-added industrial (nonfood) products from agricultural commodities or processing byproducts and wastes.

4.1.2—Foods and Food Ingredients
Identify markets and develop technologies that lead to value-added foods and food products from agricultural commodities or processing byproducts.

4.2—Safety

Improve the safety of agricultural products, byproducts, and foods.

4.2.1—Naturally Occurring Toxic Factors

Identify and develop ways to prevent, control, or eliminate toxic factors of natural origin from food and other commodities.

4.2.2—Extrinsic Toxic Factors

Identify and develop ways to prevent, control, or eliminate toxic factors of external origin from food and other agricultural commodities.

4.3—Postharvest Losses and Quality Changes

Control pests and regulate quality in order to expand domestic and export market opportunity, transport, and acceptability for agricultural commodities.

4.3.1—Pests

Develop improved methods for controlling postharvest losses caused by insects and microorganisms.

4.3.2—Quarantine Treatments

Develop technologies to meet domestic/foreign quarantine and similar requirements that restrict the movement and trade of commodities and products.

4.3.3—Quality Regulation & Control

Devise means to regulate those physiological mechanisms governing postharvest quality and shelf life in agricultural commodities.

4.4—Quality Definition/ Assessment/ Grading

Facilitate and expand trade by defining and efficiently measuring the marketable properties of agricultural commodities.

4.4.1—Quality Determinants

Define and characterize the desired physical, chemical, and aesthetic properties of agricultural commodities.

4.4.2—Quality Measurement

Devise methods to measure the critical processing and end-use properties of agricultural commodities important to the agricultural marketing system and to the processing industry.

5—Human Nutrition and Well-Being

Develop technology for promoting optimum human health and well-being through improved nutrition and family resource management.

5.1—Nutritional Requirements of Humans

Define the energy and nutrient requirements and safe ranges of intakes for humans.

5.1.1—Infants, Children, and Adolescents

Establish requirements and safe ranges of energy and nutrient intakes of infants, children, and adolescents.

5.1.2—Pregnant and Lactating Women

Establish requirements and safe ranges of energy and nutrient intakes of pregnant and lactating women.

5.1.3—Requirements and Risk Factors in Adults

Establish requirements and safe ranges of energy and nutrient intakes for adult humans, including the elderly, with emphasis on reducing risk-associated chronic disorders.

5.1.4—Nutrition and Aging Relationships

Establish requirements and safe ranges of energy and nutrient intakes of the elderly and determine the relationship between nutrition and aging.

5.2—Food Composition and Bioavailability

Determine the composition of agricultural commodities and processed foods as eaten and establish the bioavailability of their nutrients that affect health.

5.2.1—Food Composition

Generate essential data on the composition of foods (nutrients and other health-promoting constituents) as consumed in the United States, with emphasis on development of appropriate methodologies and standards.

5.2.2—Bioavailability

Determine bioavailability of nutrients in foods as consumed.

5.3—Nutritional Status and Well-Being

Improve the nutritional status of humans and the well-being of families by making techniques available for assessing effectiveness of nutrition and home economics programs.

5.3.1—Nutritional Status Assessment

Develop reliable, efficient, and cost-effective methods for defining nutritional status, evaluating nutrition action programs, and identifying properties in foods that promote good health.

5.3.2—Family Economy
Develop methods for improving family economic stability and security.

6—Systems Integration

Develop integrated systems for efficiently producing, processing, and marketing agricultural products to meet human needs while improving the natural resource base.

6.1—Resource Management: Systems and Models

Develop systems for managing resources, energy, and crops that will increase output per unit input, conserve basic resources, and enhance environmental quality.

6.1.1—Improvement and Integration
Develop holistic models that predict the integrated effects of atmospheric chemical composition, climate, and management practices on productivity, water, energy, and trace gas balance of terrestrial ecosystems, ranging from field to global scales; develop, test, and demonstrate economically productive, environmentally compatible farming systems.

6.2—Crop Production and Protection Systems

Develop and evaluate plant production/protection systems and models for improved production efficiency, stress tolerance, protection, and environmental safety.

6.2.1—Models and Systems
Develop models of production systems to evaluate alternative biological, economic, and management components that will maximize plant protection, stress tolerance, production efficiency, product quality, and environmental compatibility.

6.3—Animal Production Systems

Develop and evaluate animal production systems to improve production efficiency, enhance environmental compatibility, and decrease animal stress.

6.3.1—Total Production Systems Integration
Develop integrated production systems to improve biological and economical efficiency of animal production.

6.3.2—Production Systems/Environment
Develop production systems to evaluate all components of animal production in harmony with improved water and environmental quality.

6.4—Systems/ Models—Conversion/ Delivery

Develop integrated systems that promote the efficiency of processing, storing, distributing, marketing, and exporting agricultural products.

6.4.1—Model/Expert Systems

Develop and integrate models and predictive systems that will reduce costs of the commodities or products delivered and improve their quality and safety.

6.5—Human Nutrition Systems and Models

Devise systems to identify and alleviate potential nutritional problems of population subgroups.

6.5.1—Analysis Models

Devise procedures to evaluate the nutritional adequacy of diets of specific population subgroups and solve problems that are identified.

6.6—Systems Technologies

Develop technologies to assess risk and facilitate the integration of scientific knowledge of agricultural production, processing, and marketing into systems that optimize resource management, improve environmental quality, and facilitate transfer of technology to users.

6.6.1—Risk Assessment

Develop systems models that assess human and environmental risks from contaminants associated with agricultural production systems.

6.6.2—Systems Integration Technologies

Integrate agriculture production system information to facilitate development of technologies for improving management decisions and strategies.

6.6.3—Research Priority Assessment

Integrate global agricultural production system information for use in development of ARS strategic plans, determination of long-term research needs, and assessment of priorities.

6.6.4—Production Systems Efficiency

Link output from agricultural system component models into integrated systems to increase the efficiency of production, processing, and marketing of agricultural products while improving the environment.

Appendix C — December 1985 and June 1991 Allocations by Program Plan Objective, Approach, and Approach Elements

Appendix C tables record fund allocations to ARS locations for 1985 and 1991 by approach element, with approach totals. Small discrepancies between approach element allocations and approach totals are due to rounding.

Program totals (gross) are: Dec 85—$486,971,000; Jan 91—$621,709,000; Change—$134,738,000

Table 1. Allocations for Objective 1. Soil, Water, and Air

Approach/Approach Element[1]	$000, Gross Dec 85	Jun 91	Change
1.1 Assessment Technology			
1. Land	3,264	3,300	36
2. Water	3,241	8,424	5,183
3. Air	1,225	3,841	2,616
Total	***7,730***	***15,565***	***7,835***
1.2 Land			
1. Erosion	5,932	6,250	318
2. Soil Fertility	12,693	8,539	[4,154]
3. Physical Condition	2,397	5,031	2,634
4. Soil Biology	317	3,613	3,296
Total	***21,339***	***23,433***	***2,094***
1.3 Water			
1. Plant Use	8,079	7,151	[928]
2. Watershed Management	10,816	17,736	6,920
3. Irrigation	6,621	9,134	2,513
Total	***25,516***	***34,021***	***8,505***
1.4 Systems			
1. Management	7,523	9,586	2,063
Objective 1 Total	***62,108***	***82,605***	***20,497***

[1]For ease of comparison, labels for approach elements are based on 1985 definitions, not the 1991 revisions.

Table 2. Allocations for Objective 2. Plant Productivity

Approach/Approach Element[1]	$000, Gross		
	Dec 85	Jun 91	Change
2.1 Germplasm			
1. Plants	11,465	31,722	20,257
2. Beneficial Organisms/Pests	6,323	4,840	[1,483]
3. New Crops	1,416	1,312	[104]
Total	***19,204***	***37,874***	***18,670***
2.2 Modify Germplasm			
1. New Methods	8,484	14,407	5,923
2. Range/Pasture/Forage	5,524	4,266	[1,258]
3. Field Crops	15,594	14,332	[1,262]
4. Horticultural Crops	11,904	11,784	[120]
5. Beneficial Organisms/Pests	1,498	1,836	338
Total	***43,004***	***46,625***	***3,621***
2.3 Production Quality			
1. Basic Biology	18,974	24,506	5,532
2. Range/Pasture/Forage	8,159	11,486	3,327
3. Field Crops	2,450	2,446	[4]
4. Horticultural Crops	3,703	6,075	2,372
5. Pollination/Honey	2,925	4,494	1,569
6. Equipment Efficiency	5,486	6,173	687
Total	***41,697***	***55,180***	***13,483***
2.4 Protection			
1. Biology of Insects	21,342	13,476	[7,866]
2. Biology of Plant Pathogens	15,210	13,667	[1,543]
3. Biology of Nematodes	2,113	2,477	364
4. Range/Field/Horticultural Crops	23,745	28,623	4,878
5. Weed Biology	7,029	6,077	[952]
6. Weeds, Other	3,142	4,171	1,029
7. Weeds of Field/Horticultural Crops	3,287	3,993	706
8. Biological Control	6,175	19,059	12,884
9. Agricultural Chemicals Technology	6,063	9,914	3,851
10. Vertebrate Pests	215	0	[215]
Total	***88,321***	***101,457***	***13,136***
Objective 2 Total	***192,226***	***241,136***	***48,910***

[1]For ease of comparison, labels for approach elements are based on 1985 definitions, not the 1991 revisions.

Table 3. Allocations for Objective 3. Animal Productivity

Approach/Approach Element[1]	$000, Gross Dec 85	Jun 91	Change
3.1 Genetics			
1. Selection	5,837	4,506	[1,331]
2. Biochemical Genetics	300	3,325	3,025
3. Disease Resistance	383	3,055	2,672
Total	***6,520***	***10,886***	***4,366***
3.2 Reproduction			
1. Offspring Reared	5,126	5,725	599
2. Germ Cell/Embryo	1,769	3,230	1,461
3. Lactation	1,857	1,328	[529]
Total	***8,752***	***10,283***	***1,531***
3.3 Nutrition			
1. Nutrient Limits	3,722	5,358	1,636
2. Nutrient Losses	4,723	7,900	3,177
3. Synthesis/Composition	3,664	6,753	3,089
Total	***12,109***	***20,011***	***7,902***
3.4 Disease			
1. Diagnosis	7,882	10,555	2,673
2. Stress/Disease	3,525	2,082	[1,433]
3. Pathogenesis	13,782	16,857	3,075
4. Disease Control	15,127	18,713	3,586
5. Toxicology	4,894	4,373	[521]
Total	***45,210***	***52,580***	***7,370***
3.5 Insects/Ticks/Mites			
1. Detection	1,041	531	[510]
2. Mechanisms	553	1,218	665
3. Reduced Losses	5,374	6,974	1,600
4. Integrated Systems	5,225	2,504	[2,721]
5. Human Protection	1,769	2,470	701
Total	***13,962***	***13,697***	***[265]***
3.6 Systems			
1. Stress/Environment	835	1,459	624
2. Integrated Systems	4,500	3,176	[1,324]
Total	***5,335***	***4,635***	***[700]***
Objective 3 Total	***91,888***	***112,092***	***20,204***

[1]For ease of comparison, labels for approach elements are based on 1985 definitions, not the 1991 revisions.

Table 4. **Allocations for Objective 4. Commodity Conversion and Delivery**

Approach/Approach Element[1]	$000, Gross		
	Dec 85	Jun 91	Change
4.1 Commodities/Products			
1. Characteristics	17,728	27,841	10,113
2. Mechanisms	15,974	15,129	[845]
3. Regulation	2,338	2,317	[21]
4. Processing	16,695	18,473	1,778
Total	***52,735***	***63,760***	***11,025***
4.2 Safety			
1. Intrinsic	7,126	4,122	[3,004]
2. Extrinsic	12,026	24,295	12,269
Total	***19,152***	***28,417***	***9,265***
4.3 Loss Reduction			
1. Insects	9,589	15,064	5,475
2. Microbes	4,289	3,947	[342]
3. Deterioration	3,350	2,496	[854]
Total	***17,228***	***21,507***	***4,279***
4.4 Systems			
1. Inefficiencies	893	0	[893]
2. Concepts	761	645	[116]
3. Grading	1,266	1,882	616
4. Exports	1,179	1,425	246
Total	***4,099***	***3,952***	***[147]***
Objective 4 Total	***93,214***	***117,636***	***24,422***

[1]For ease of comparison, labels for approach elements are based on 1985 definitions, not the 1991 revisions.

Table 5. Allocations for Objective 5. Human Nutrition and Well-Being

Approach/Approach Element[1]	$000, Gross		
	Dec 85	Jun 91	Change
5.1 Nutrient Requirements			
1. Infants/Children	3,059	8,487	5,428
2. Pregnant/Lactating/Women	2,242	4,702	2,460
3. Adults	8,239	17,075	8,836
4. Aging	14,596	12,423	[2,173]
Total	***28,136***	***42,687***	***14,551***
5.2 Nutrient Composition/Bioavailability			
1. Composition	1,545	1,567	22
2. Bioavailability	6,008	6,515	507
Total	***7,553***	***8,082***	***529***
5.3 Nutritional Status Evaluation			
1. Food Consumption	1,358	476	[882]
2. Status Methodology	1,580	2,022	442
3. Family Economy	474	624	150
Total	***3,412***	***3,122***	***[290]***
5.4 Integration			
1. Strategies	358	251	[107]
Objective 5 Total	***39,459***	***54,142***	***14,683***

[1]For ease of comparison, labels for approach elements are based on 1985 definitions, not the 1991 revisions.

Table 6. Allocations for Objective 6. Systems Integration

Approach/Approach Element[1]	$000, Gross		
	Dec 85	Jun 91	Change
6.1 Integrated Systems			
1. Conservation/Production	4,262	10,249	5,987
2. Export	549	383	[166]
3. Remote Sensing	3,265	3,466	201
Objective 6 Total	***8,076***	***14,098***	***6,022***

[1]For ease of comparison, labels for approach elements are based on 1985 definitions, not the 1991 revisions.

Appendix D. Examples of Research Progress, 1984 and 1986 Areas of Research Emphasis

Objective 1. Soil, Water, and Air

Develop the means for managing and conserving the Nation's soil, water, and air resources for a stable and productive agriculture.

1984 Research Emphasis

Efficient and accurate methods for assessing condition of the soil and water resource base.

Models for Predicting Soil Erosion

Develop innovative methods based on scientific concepts for predicting soil erosion by wind and water for a wide range of land uses and treatments.

Progress

- A new generation of erosion prediction technology, based on innovative concepts in hydrology, hydraulics, and soil science. This technology, which was developed by an interdisciplinary team of scientists from ARS, other Federal agencies, and State institutions as part of the Water Erosion Prediction Project (WEPP), was delivered to key resource management agencies in 1989.

Hydrologic Applications of Remote Sensing

Develop methods for measuring snow cover, vegetative biomass, plant stress, soil moisture, water quality, and evapotranspiration using remote sensing from aircraft and satellites.

Progress

- Method for estimating the water content of the surface layer of cropland and rangeland soils, based on remotely sensed radiation signals in the radar wavelength range.
- Methods for estimating plant water stress from remotely sensed crop canopy temperatures using emitted radiation in the infrared range.
- Stereophotogrammetric methods for measuring changes in gully growth.
- Measurement of suspended sediment concentrations in rivers, lakes, and reservoirs based on the reflectance of incoming radiation in the red and near infrared range of the electromagnetic spectrum.

1984 Research Emphasis

Databases for land/water systems analysis and predictive modeling.

Soil/Pesticide Database

Develop a database on pesticide properties and on major soil and pesticide groups for use in water quality models.

Progress

- A database of physical and chemical properties for 92 pesticides and a grouping of soils and pesticides into classes based on soil taxonomy and pesticide persistence and solubility. USDA's Soil Conservation Service (SCS) and the National Agricultural Chemical Association (NACA) collaborated with ARS on this project.

- The soil and pesticide information obtained from the first phase of this database development project was delivered to SCS in 1990 and will be used to improve the predictive capability of water quality models.

1986 Research Emphasis

Improved technology for preventing or reducing ground water contamination by agricultural chemicals.

Water Quality Initiatives

Improve coordination of Federal and State research programs on water quality protection.

Progress

- Formation of an interagency working group on water quality to promote the President's Water Quality Initiative of 1990. The Departments of Agriculture and the Interior, the Environmental Protection Agency, and the State agricultural experiment stations are represented.

- Establishment of Management Systems Evaluation Areas in five Midwestern States and satellite locations in four other States, with Federal and State participation in development of alternative systems for agricultural production and chemical management.

Water Quality Prediction and Management

Develop and evaluate models for predicting effects of agriculture on water quality and determine the effectiveness of different farm and resource management practices in reducing movement of agricultural chemicals to ground water.

Progress

Among the findings:

- Water quality models, such as the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS), will predict the effects of many resource management practices on ground water quality.

- Controlled drainage reduces nitrate releases to surface and subsurface waters in the Coastal Plains by as much as 50 percent.

- Riparian zones remove nitrate from shallow ground water and reduce by 75 to 95 percent the loading of streams by sediments and plant nutrients.

- Winter cover crops, such as ryegrass, remove as much as 80 percent of residual nitrate from the soil profile.

1986 Research Emphasis

Efficient and accurate methods for assessing soil salinity and effective measures for controlling the leaching of salts and toxic elements into drainage waters.

Soil Salinity Mapping

Develop cost-effective methods for mapping soil salinity at field and regional scales.

Progress

- For small areas, several electrical conductance methods of varying size to assess trends in soil salinity.
- For large-scale regional assessments, a new method suitable for use by irrigation district managers and policymakers. This method uses a few in-situ geophysical measurements of electrical conductivity, soil maps, and data from marine navigation satellites for accurately relocating monitoring sites.

Salinity Management

Reduce the leaching of salts and toxic elements into drainage waters through better on-farm water management.

Progress

- Experimental verification that level-basin irrigation will keep soil salinity at levels that do not restrict plant growth.
- Alternative water management and irrigation scheduling procedures capable of reducing salt loading of the Colorado River by almost 30 percent.
- Proven potential of crops, such as mustard, to reduce the amounts and concentrations of the toxic element selenium in soil and drainage waters.

Objective 2. Plant Productivity

Develop the means for maintaining and increasing the productivity and quality of crop plants.

1984 Research Emphasis

Acquisition and maintenance of the genetic diversity of plants.

Germplasm Management

Acquire and maintain a broader base of genetic diversity for crop improvement programs. Expand capability for preservation, evaluation, and enhancement of germplasm.

Progress

- Completion of Germplasm Resources Information Network (GRIN) database software, including a new public system for users.
- Implementation of priority collection program for plant germplasm.
- Implementation of new protocols for germplasm regeneration and pre-storage management for all crop plants.
- Establishment of dwarfing fruit tree germplasm to control tree size, reduce volume of pesticide applications, and reduce the use of chemical plant growth regulators.

Germplasm Modification

Select and modify germplasm of plants, beneficial organisms, and pests.

Progress

- Identification of quantitative trait loci (QTL's) in corn.
- Manipulation of QTL's with molecular markers, such as isozymes and restriction fragment length polymorphisms.
- Identification of storage proteins (gliadins and glutenins) that contribute to the quality of hard red winter wheat.
- Successful gene transfer systems, tissue culture regeneration, and rapid multiplication of pathogen-free, asexually propagated material.

1986 Research Emphasis

Innovative and efficient methods for pest control and management.

Biologically Based Control

Develop improved, safe, effective, and environmentally compatible means to control and manage insects, weeds, and pathogens.

Progress

- Wheat varieties that are resistant to the Hessian fly and to strawbreaker foot rot.
- A new attracticide that is specific to the boll weevil and that does not destroy beneficial arthropods.
- A novel pest population suppression system that controls corn rootworms using a combination of semiochemical attractants and feeding stimulants with very low levels of insecticides.
- Satellite-virus-mediated protection of tomato plants against the cucumber mosaic virus.

- Ceralure, a new medfly attractant that reduces the need for aerial bait sprays.

- Pheromones that inhibit the mating of peach tree borers.

- Isolation and cloning of genes associated with the regulatory hormones that control pheromone biosynthesis to inhibit the mating of insects.

- A new nozzle design that allows ultra-low-volume applications of postemergence herbicides in oil with twofold to fourfold reductions in herbicide use.

- Microbial fungicides that control soilborne diseases of vegetables, wheat, cotton, and ornamentals.

- Computer models that use predicted weed populations and their effect on crop yield to optimize herbicide application rates.

1986 Research Emphasis

Technologies for lowering production costs and improving product quality.

Oilseed Crops

Develop a genome map for soybeans.

Progress

Construction of skeletal genome maps from two populations for use in improving disease resistance and seed oil and protein content.

Fiber Crops

Accelerate research on enhanced cotton growth simulation models and develop computerized decision-aid models for cotton growers.

Progress

- Implementation of decision-aid models for cotton producers to optimally manage water and nitrogen and schedule crop termination.

Forage Crops

Develop new varieties with increased yield potential, adaptation, and quality.

Progress

- Hycrest wheatgrass that is more drought tolerant, easier to establish, and 50 percent more productive than previous varieties.

- Nitro alfalfa that fixes 30 percent more nitrogen during the growing season than standard alfalfa varieties.

- Tifleaf 2, a hybrid pearl millet that yields as much as 22 percent more than other varieties and is highly preferred by cattle.

- WW Spar, an old world bluestem that is drought tolerant, controls erosion, and has been planted on more than 1 million acres of marginal land in the Southern Plains.

Fruit Crops
Develop practices and farming systems to reduce production costs for horticultural crops.

Progress

- Development of a system for rapid micropropagation of apples that reduces the cost of orchard establishment.

1984/1986 Research Emphasis

Technologies for gene transfer and expression and methods for controlling basic biological processes relating to crop growth, environmental stresses, pest resistance, and yield.

Molecular Biology
Develop means to transfer genes or regulate gene expression to control plant characteristics at molecular level.

Progress

- Genetic transformation of corn to express marker genes. This new genetic tool is capable of transforming other monocot food and feed grain crops such as wheat, oats, and barley.

- Gene systems that encode the specific enzymes responsible for breaking down large protein, carbohydrate, and fat molecules into smaller units capable of being translocated to leaves, stems, and roots where they are used to build components of the three plant organs.

- Location of yield genes on corn chromosomes.

Objective 3. Animal Productivity

Develop the means to increase the productivity of animals and the quality of animal products.

1986 Research Emphasis

Physiological and biochemical approaches for controlling genetic variation and resistance to diseases, parasites, and arthropods.

Animal Model Evaluations for Dairy Genetics
Increase the production efficiency of dairy cattle by controlling their genetic variation. Traditional genetic evaluation of dairy cows is based on individual production history and sire's genetic evaluation.

Progress

- New and improved genetic evaluation system for dairy cattle; that includes accumulated maternal line information without increased computing costs. In 1990, evaluations for 87,000 bulls and over 10 million cows were distributed to breeders and researchers in the United States and 30 foreign countries. Benefits to production efficiency, semen sales, and the export of embryos and cattle are in the range of $100 million annually.

1986 Research Emphasis

Knowledge of how specific genes improve production and reproduction efficiency and animal product quality.

Technologies for Animal Genetics and Reproduction

Develop methods and programs in biochemical genetics, gene manipulation, and gene transfer for improving production efficiency.

Progress

- Through genetic selection, an increase from 10 percent to 23 percent in the twinning rate for beef cattle.

- Method for separating the X from the Y chromosome-bearing sperm in farm animals that gives 95 percent accuracy in predetermining the sex of offspring.

1986 Research Emphasis

Methods for reducing fat and increasing protein tissues in animals and animal products.

Multidisciplinary Approach to Reduction of Fat Content

Develop genetic, physiological, and nutritional means to reduce fat content.

Progress

- Demonstration that use of recombinant porcine somatotropin increases the rate of gain in body weight by 10-15 percent in growing hogs, reduces the quantity of feed required per unit of gain by 25 percent, increases edible meat yield by 8 percent, and reduces fat deposition by 40-80 percent.

- Pioneering developments in gene insertion technology and production of transgenic swine and sheep. Fat content of the transgenic swine is reduced by 80 percent, and the new genetic makeup is passed on to later generations.

- Demonstration that regulating the feed intake in early life of broilers alters body composition at market weight to 20 percent less carcass fat.

- Demonstration that, with the aid of growth promoters, ruminants deposit 25 percent more protein, have larger rib eyes, have 10 percent less carcass fat, and grow with the same energy efficiency.

1986 Research Emphasis

Knowledge of ways to apply recombinant DNA technologies to diagnose foreign and domestic diseases, parasites, and arthropods.

Recombinant DNA Technologies for Disease Diagnosis

Improve diagnostic methods for identifying disease-causing agents and methods for assessing losses.

Progress

- Successful use of recombinant nucleic acid technologies to develop DNA probes to detect and identify several important livestock pathogens. These gene probes provide unprecedented specificity in detecting and identifying disease-producing agents, with significant lowering of diagnosis time. DNA probes are now used to detect causative agents of swine dysentery, Johne's disease, leptospirosis, and anaplasmosis.

Objective 4. Commodity Conversion and Delivery

Develop technology for enhancing domestic and global market demands.

1984/1986 Research Emphasis

Objective methods of grading agricultural commodities.

Wheat Classification

Develop an objective system for differentiating hard from soft and spring from winter classes of wheat. New wheat varieties do not fit the traditional visual classification system.

Progress

- Development of a rapid objective method, using near infrared reflectance spectroscopy (NIRS), for measurement of wheat hardness; now accepted by the wheat industry as a reference method.

- Development of two concepts and instruments for measuring single-kernel hardness, one of which meets Federal Grain Inspection Service performance criteria for speed, accuracy, and reproducibility.

- Development of an NIRS method for differentiating spring and winter wheats.

Cotton Grading

Provide a logical basis for marketing of cotton for use by both USDA's Agricultural Marketing Service and the cotton industry.

Progress

- Instrumentation for measuring the commercially important properties of cotton fibers, such as strength, length, diameter, and color. Starting in 1991, all cotton included in the Government's loan program will be graded using this new technology, which is termed High Volume Instrumentation (HVI).

1984/1986 Research Emphasis

Basic mechanisms of biodeterioration in postslaughter animal materials.

Catfish Flavor

Solve the problem of off-flavor, or unpleasant flavor, in farm-raised catfish.

Progress

- Development of standardized terminology for catfish flavor now adopted by the industry for use in flavor-quality control.
- Identification of the off-flavor causative agents as metabolites of pond microorganisms.
- Identification of the biosynthetic pathway producing off-flavor metabolites in pond microorganisms and some of the environmental triggers.
- Development of immunoassays for the offending metabolites.
- Identification of the factors controlling the uptake and purging of metabolites in live fish.

1984/1986 Research Emphasis

Mechanisms of deterioration in harvested fruits and vegetables.

Ripening Process

Characterize key aspects of the ripening process in order to identify useful targets for reducing deterioration through genetic alteration.

Progress

- Demonstration that cell wall biosynthesis continues during ripening and softening.
- Demonstration that cell wall pectin is a loosely held, easily dissociated polymer that does not require enzymes to be degraded.
- Cloning of the gene ACC synthase, a key enzyme in the biosynthesis of the plant-ripening hormone ethylene.

1984/1986 Research Emphasis

Reduced microbiological contamination of meat and poultry products.

Pathogens in Live Animals

Eliminate human food pathogens in live animals before slaughter to complement other measures that ensure safe consumer-ready food.

Progress

- A sugar, lactose, that prevents colonization by *Salmonella* in newly hatched chickens.

- Specific bacterial flora that prevent *Salmonella* colonization in the fowl gut.
- A poultry production management system that complements these specific treatments.

1984/1986 Research Emphasis

Prevention of mycotoxin contamination in major crops.

Aflatoxin and Fusarium Toxins

Provide practical means for controlling aflatoxin and the fusarium toxins in mycotoxin-prone crops.

Progress

- Promising biological agents for controlling growth of mycotoxin-producing fungi.
- Improved understanding of ecological relationships between the host crop, mycotoxin-producing fungi, and insects.
- Identification of attractants to reduce the population of insects that carry *Aspergillus flavus* or provide entry points into the plant.
- Specific information on the environmental conditions necessary for aflatoxin production in peanuts, thus providing the opportunity to produce peanuts with practically no aflatoxin contamination.

I984/1986 Research Emphasis

Conversion of surplus commodities into competitive or new products that add value and open new domestic and export markets.

New Foods and Nonfood Uses

Develop processes to convert major commodities to new nonfood products and new value-added food products and to expand uses for agricultural fibers.

Progress

- Use of soybean oil to reduce dust emissions and explosion hazard in stored grain.
- Conversion of cornstarch to bioplastics and pesticide-encapsulating agents.
- Conversion of oat bran and milk whey proteins into fat substitutes.
- A superior new (nonformaldehyde) permanent-press system.
- Fiber-reinforced yarn and temperature-responsive fabrics.

1984/1986 Research Emphasis

Elimination of insect and microbial contaminants that are barriers to export markets.

Alternative Treatments for Stored-Product Insects

Develop new and improved treatments for controlling insects in stored products to increase the acceptability of U.S. commodities in foreign markets.

Progress

- Improved methods of in-transit fumigation of grain.
- Development of a fumigation schedule for codling moth in fresh nectarines that is acceptable to the Japanese market.
- Development of a treatment process for codling moth in in-shell walnuts.
- Development of a rapid assay for determining the viability of Fuller rose beetles in citrus.
- Biological alternatives to fumigation for the codling moth using synthetic pheromones to disrupt mating.

Objective 5. Human Nutrition and Well-Being

Develop the means for promoting optimum human health and well-being through improved nutrition and family resource management.

1986 Research Emphasis

Improved knowledge of nutritional requirements for infants, children, pregnant and lactating women, and the elderly.

Requirements of Infants and Lactating Women

Define the dietary needs of infants and lactating women.

Progress

Among the findings:

- The energy requirement for breast-fed infants is substantially below present international recommendations.
- Immune factors in breast milk significantly improve disease resistance.
- Fortification of human milk with calcium and phosphorus supplements and with added breast milk proteins is important in the early growth and development of low-birth-weight infants.
- Young infants absorb and metabolize rice starch.

- Dietary fat intake influences the content and composition of the fat in the milk of lactating women.

- Stable isotopes, rather than the radioactive isotopes used in animals, can be used in humans to estimate minimal requirements for protein.

Requirements of the Elderly

Determine the nutritional needs of the elderly.

Progress

Among the research findings:

- Dietary requirements for protein and vitamin B6 are higher in the elderly.

- Aging individuals with atrophic gastritis have increased dietary requirements for vitamin B12 and folacin due to poor absorption and utilization.

- Higher vitamin E intake improves the immune response in the elderly.

- The onset of cataracts in older persons is inversely proportional to their intake of vitamin C and other antioxidant nutrients.

1986 Research Emphasis

Improved understanding of the relationship of diet to health maintenance.

Diet as Related to Risk Factors

Define the role of dietary fat and fibers as risk factors for chronic diseases.

Progress

Among the findings:

- Both the level and type of dietary fat influence blood cholesterol levels; blood pressure is inversely related to the amount of linolenic acid eaten; and linolenic acid functions metabolically as an omega-3 fatty acid.

- High-fat diets lead to significantly greater levels of fecal mutagens.

- Type and level of complex carbohydrates and dietary fiber affect blood glucose tolerance.

- Calcium supplementation after menopause reduces the rate of bone density loss in women.

1986 Research Emphasis

Methods for assessing nutritional status and effect of food consumption.

Methods for Nutritional Assessment

Improve methods for measuring body fat, vitamin A status, and food intake.

Progress

- A rapid computerized method for dietary assessment of food and nutrient intake.
- Improved methods of measuring vitamin A status and body composition.
- Measurable effects of marginal nutrition on immune response and behavior.

1986 Research Emphasis

Improved methods for analyzing and determining the bioavailability of food components.

Bioavailability of Trace Elements

Develop methods for measuring the bioavailability of trace elements, emphasizing availability of minerals and the effect of nutrient interactions in total diets on digestion and absorption.

Progress

Among the findings:

- Sensitive methods developed to measure human absorption of calcium, copper, iron, magnesium, manganese, and zinc, using isotopes of these elements.
- Copper, manganese, and zinc are absorbed similarly whether grown naturally in various foods or added during final food preparation.
- Ascorbic acid improves iron retention by iron-depleted women fed a diet with poorly available iron for several weeks.
- About one-fourth of the essential dietary element zinc is absorbed from an ordinary U.S. diet; this information allows better estimates of dietary need and more reliable recommendations for food consumption.

Appendix E — ARS Implementation Policies

Policy 1—National Planning and Coordination

The Administrator will operate ARS as a managed activity coordinated by plan.

The ARS Program Strategy describes the research needed to respond to the formidable challenges facing U.S. agriculture. ARS, the principal intramural research agency in USDA, is in turn challenged to focus its scientific resources on the timely solution of the problems it addresses. The ARS Administrator will ensure that needed plans are developed, updated periodically, and implemented to deploy the physical and human resources of ARS to that end. Such plans will provide a framework and sound foundation for:

- Assigning responsibilities for program and administration within the agency.
- Coordinating research across ARS programs and geographic units to ensure effective teamwork and to minimize duplication.
- Coordinating ARS research programs with progress of other research institutions, such as the State agricultural experiment stations and industry, to ensure that efforts are efficient and complementary.
- Meeting the research needs of those who use agricultural research, including other Federal agencies.
- Setting priorities for allocating and redirecting resources and developing budget requests to promote scientific excellence and to use the talents of the agency more efficiently.
- Ensuring that effort is productive and balanced among the six ARS Program Plan objectives and their subdivisions.
- Ensuring that problems are addressed by the most appropriate means in terms of key scientific disciplines, teamwork, and technical approach.
- Ensuring that physical and financial resources are available and used effectively.
- Reviewing and evaluating progress toward achievement of the objectives.
- Enhancing the opportunity for ARS scientists to apply their expertise innovatively to critical regional, national, and international problems.

The 6-Year Implementation Plan will be the key document in the overall ARS Program Plan. Development and maintenance of the 6-year plan are responsibilities of the Deputy Administrator, who directs the ARS National Program Staff (NPS). Working with line managers, NPS—in accordance with the plan—will assess the full spectrum of scientific needs of the agency, assess the resources that are available for reassignment, and identify program areas that lack resources. Based on the results of that work, NPS will develop options and provide to the Deputy Administrator recommendations for resource allocations.

The Deputy Administrator is responsible for resource allocations to research programs and projects within the framework of policies and guidelines established by the Administrator, Department, and Congress. Line managers—including area, center, and laboratory directors and research leaders—are responsible for research program implementation. The Administrator, NPS, and the ARS Budget and Program Management Staff will develop budget proposals for submission to the Department. Periodically, NPS will adjust the 6-year plan based on budgetary decisions and national priorities. Line managers are responsible for updating their operational plans, in accordance with those decisions and priorities, and for implementing their plans. ARS scientists are responsible for keeping staff members and line managers abreast of the latest scientific advances and opportunities for progress and for ensuring the scientific excellence of their programs. A coordinated ARS effort will ensure that public resources are expended on scientifically excellent and innovative efforts directed toward high-priority problems.

Policy 2—Determination of Program Content

The ARS research program will include the full range of activities needed to achieve the six program plan objectives.

For steady progress toward achieving the six program plan objectives, ARS will balance its efforts between fundamental and applied research to solve technical agricultural problems. Fundamental research produces knowledge that is an essential scientific resource. In their applied research, ARS scientists will draw on that resource to meet the immediate needs of USDA action agencies, other Federal agencies, and users of ARS research findings. By maintaining the balance between fundamental and applied research, ARS will fully address the critical problems presented in the six objectives and their subdivisions. ARS programs will emphasize long-term, high-risk research. Interdisciplinary research teams will be formed, reorganized, and redirected as needed to ensure that effort is efficiently focused and that the research leads that promise the widest spectrum of benefits are pursued. ARS will concentrate on problems of regional, national, and international scope and importance. ARS will not conduct research that can be conducted better or on a more timely basis by industry or other research institutions. Cooperative research by ARS and State and industrial scientists will be encouraged as an efficient means for increasing the overall benefits that accrue from public investments in agricultural research.

Policy 3—Establishing Priorities

The Deputy Administrator is responsible for establishing priorities in the 6-Year Implementation Plan and the derived budgets. The Administrator ensures that the priorities are consistent with the goals of the Department.

The priorities established form the basis for determining program content, for operational planning, and for resource allocations in ARS in three major ways. Priorities will be the foundation for updating the 6-Year Implementation Plan and for planning annual allocations and budget requests. Priorities will guide the allocation of resources to research projects and among competing operational needs. An evaluation of progress in, and the

plans of, each research project will form the basis for allocations. Research leaders and individual scientists are responsible for determining which experimental approaches and specific lines of research to pursue within the overall mission of their laboratories.

Priority setting is complex and dynamic. It is an interactive process among staff and line scientists and includes considerations of both the scientific community and research users. Decisions by the Secretary of Agriculture, Office of Management and Budget, and the Congress will determine the ARS appropriation and can affect the allocation of funds to specific locations and areas of research. Within ARS, individual scientists, along with Area Directors and their staffs, will significantly influence priorities based on their analyses of needs for equipment, facilities, and personnel for exploiting scientific opportunities. Outside of ARS, the Joint Council on Food and Agricultural Sciences and its regional subcommittees, the Users Advisory Board, other advisory boards, leaders of farm organizations, industrial groups, and professional societies will influence priorities. The USDA action and regulatory agencies that depend on ARS for research—agencies such as the Animal and Plant Health Inspection Service, Soil Conservation Service, Extension Service, Forest Service, Food and Nutrition Service, Food Safety and Inspection Service, Agricultural Marketing Service, and Foreign Agricultural Service—will also influence priorities. At times, the research needs of agencies such as the Environmental Protection Agency, Agency for International Development, Department of Defense, National Aeronautics and Space Administration, and Bureau of Land Management will enter the process. Analyses and projections by USDA's Economic Research Service and other agencies will also be considered.

For setting of priorities, the Administrator will rely on the Deputy Administrator and NPS to plan, articulate, and evaluate national ARS programs. NPS identifies research opportunities, research that is conducted by other organizations, and research needs that are expressed by user and advisory groups. NPS develops recommendations for program redirections and budget requests. As the direct recipient of the information described above, the Deputy Administrator will establish and articulate ARS priorities and allocate resources accordingly. NPS will update the 6-Year Implementation Plan and, with the ARS Budget and Program Management Staff, develop budgets for the plan.

The main criteria for setting priorities and allocating resources will be:

- Consistency with the objectives and goals of Congress, the Department, and ARS.
- Need for the research as expressed by ARS scientists, user groups, Federal agencies, and the general scientific community.
- Potential benefits expected from achieving the stated objectives.
- Research capabilities and capacity of the scientists, laboratory, or program.
- Probability of success.
- Cost of conducting the research.
- Amount and kind of research effort conducted by other research organizations.

Several factors may limit the allocation of resources and kinds of research that ARS conducts and its flexibility in use of resources. The following factors, which include major limitations, must be considered:

- Availability of scientific expertise. Successful research depends on the training and experience of individual scientists and on the teamwork that evolves within and among laboratories. For both individuals and groups, many years are required to reach peak productivity.

- Geography, climate, and soil. For valid results, certain types of research, especially field research, must be conducted at problem sites and over extended periods.

- Nature of the problem. Much ARS research requires costly facilities and equipment that are problem-specific. Quarantine facilities and special equipment for work on recombinant DNA and foreign animal diseases are examples.

- Sequential nature of research. Often, one phase of research must be completed before the next phase can be started.

- Continuous adaptation of biological systems. Examples are the resistance of crop pests to chemical controls and the genetic improvement of crops that may introduce new vulnerabilities. Goals and priorities must be revised to meet new problems as they arise.

No totally objective formula is possible for setting priorities and allocating resources for research. Priority setting for research is the exercise of informed judgment. It is based on the criteria and limitations listed above; all the factors are important at some level of decisionmaking. At the project level, scientific criteria and experience will predominate. At the national level, scientific criteria must be balanced with Federal policies and with the needs of action agencies and other users of research. It is the task of the Administrator, Deputy Administrator, and NPS to achieve such a balance so that ARS may provide its scientists with the long-term stability and the firm commitments that are needed for creative research.

Policy 4—Program Implementation and Management

The area directors are responsible for development and implementation of operational plans for achieving the ARS objectives. The Administrator is responsible for overall coordination and execution of the program.

ARS operates by means of coordinated line and staff activities and responsibilities. Area directors are responsible for field operations managed by directors of major research centers and research unit leaders. The Deputy Administrator is responsible for the management and operation of NPS.

NPS is responsible for developing and providing overall leadership for national research programs in accordance with policies 1 and 3. The area directors are responsible for operations and operational planning for assigned research units.

The area and center directors and scientists prepare operational plans in consultation with, and subject to review by, NPS. The area directors, working with the center directors, are responsible for the direct supervision and management of approved research programs and projects. Administrative management support services provide for personnel and for procurement, fiscal, and other functions. Area directors manage the Research Grade Evaluation and Merit Pay systems by which individual scientists and support personnel are evaluated and rewarded, including the recognition of interdisciplinary research and teamwork.

Line managers play a key role in coordinating research in ARS with that in the State agricultural experiment stations, Cooperative Extension Service, Soil Conservation Service, and other agricultural groups of State and regional scope. Through close working relationships with the directors of State agricultural experiment stations, joint research projects, cooperative agreements, and extramural projects are developed as needed to ensure efficient use of ARS personnel and resources.

Line and staff personnel will work together to maintain the integrity and scientific excellence of national programs while efficiently and effectively using ARS resources. NPS will consult with line managers and scientists in developing ARS priorities and the 6-Year Implementation Plan; the area directors will consult and review with NPS to ensure that the operational plans are consistent with the research objectives and with the priorities of the 6-year plan.

Policy 5—Review and Evaluation

The Deputy Administrator is responsible for the systematic evaluation of programs and of progress toward achievement of the 6-year plan.

Review and evaluation of research programs at many levels in the agency serve to identify areas of significant progress, major limitations to further progress, emerging research problems and opportunities, and research that can be discontinued. That information will be used in setting priorities, planning and implementing redirections, developing budgets, and revising the 6-Year Implementation Plan and the operational plans.

NPS is responsible for reviewing national programs and for evaluating their progress and consistency with the 6-year plan. To successfully carry out that responsibility, members of NPS will be recognized experts in their fields and will be expected to maintain their knowledge of the latest scientific aspects of their assigned areas of responsibility. NPS members will also need broad experience and understanding of interdisciplinary research to recognize and exploit opportunities in related fields or to function as coordinators of problem-solving interdisciplinary teams. They will be prepared to provide authoritative advice as required. NPS members, then, serve the agency as guardians of the continuing relevance and correctness of the technical directions of the ARS program.

NPS and area and center directors will have operational responsibility for reviewing and evaluating specific programs and units. In addition to the appropriate staff and line managers, review and evaluation teams can include top ARS scientists; representatives from cooperating State agricultural experiment stations, action agencies, and farm and

industrial organizations; or other knowledgeable people who can contribute. The review and evaluation teams will develop a formal list of findings and recommendations for implementation by line managers, the scientists, or members of NPS. The review team leader will then document and forward to the Deputy Administrator the plans for and the actions taken to implement the recommendations of the review and evaluation teams. Area and center directors will review, annually, each research unit and laboratory under their supervision to assess progress on the operational plans and to ensure conformance with the 6-Year Implementation Plan. Although technical matters may be considered, the main purpose of those reviews will be to evaluate operational capability and performance. The adequacy of available physical, financial, and human resources should be assessed, based on the technical objectives to be achieved. Special attention will be given to identifying opportunities for enhancing technical and leadership capabilities. Findings from and recommendations that result from those reviews will be formally communicated to the Deputy Administrator.

Scientific and technical excellence demands a continuing review and evaluation of progress by the scientists performing the work. Scientific decisions at the experimental level are best made by those scientists.

Appropriate management information systems will be developed and maintained to meet the specific needs of the Administrator and of the deputy and regional administrators.

Policy 6—International Activities

ARS conducts research and participates in technology exchange in foreign countries to complement and strengthen domestic research programs and to support international trade and development.

The Administrator has operating responsibility for ARS international activities. The Assistant to the Administrator for International Activities is responsible for management of ARS human and financial resources allocated to foreign research activities. The Deputy Administrator and NPS are responsible for planning, setting priorities, allocating resources, and evaluating international research activities that are an extension of the domestic programs described in the 6-Year Implementation Plan.

ARS also will support U.S. and foreign initiatives that directly benefit U.S. agriculture and provide a substantial contribution to world agriculture. ARS will work directly with other USDA agencies—such as the Foreign Agricultural Service, Office of International Cooperation and Development, and Animal and Plant Health Inspection Service; other non-USDA Government agencies, such as the Agency for International Development, Departments of Defense and Commerce, and the National Science Foundation; State universities; and international institutions, such as the Food and Agriculture Organization, World Bank, International Atomic Energy Agency, and World Health Organization—to produce the greatest benefits from research and technical-exchange programs.

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